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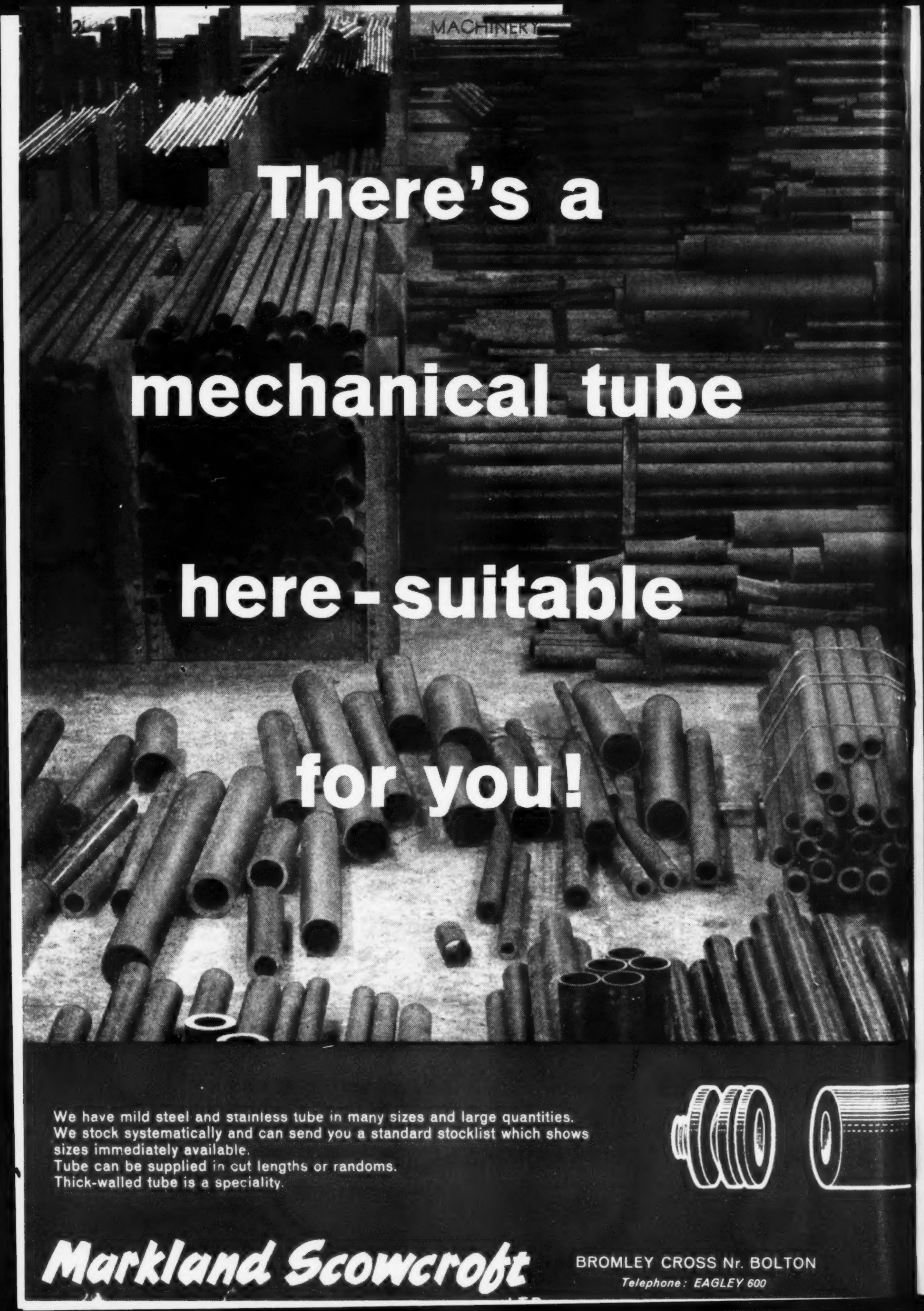

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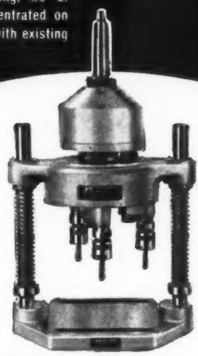

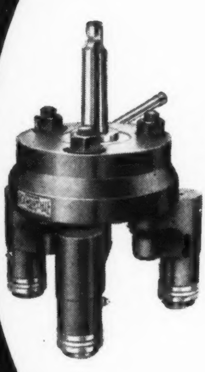

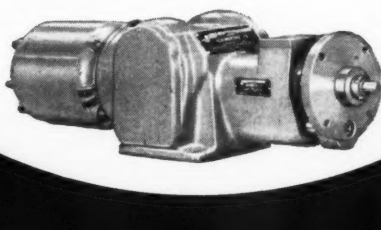

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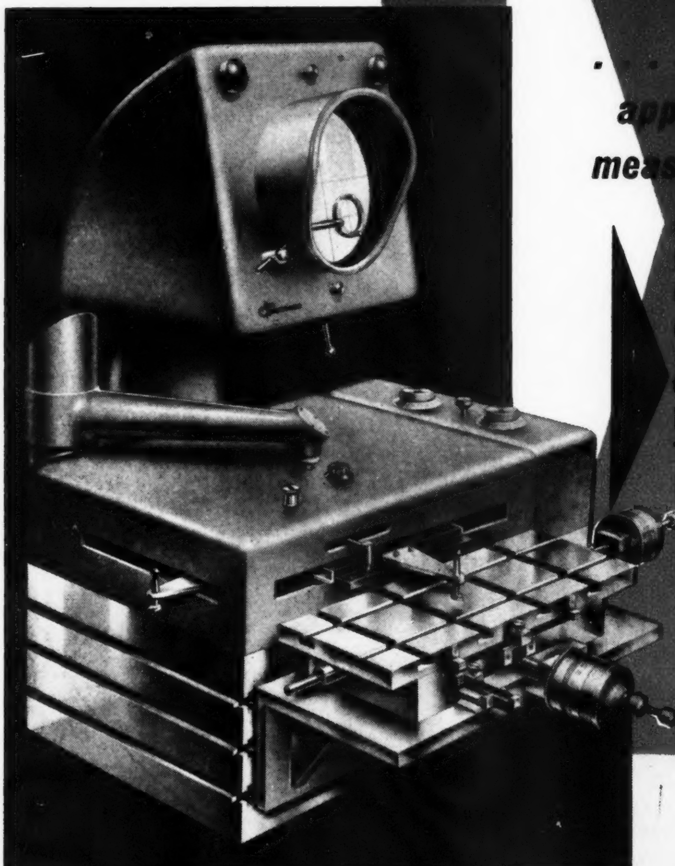

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This revolutionary instrument incorporates an entirely new technique and system for gauging both simple and intricate component forms, and dispenses with the cost and manufacture of special gauges, etc.

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4½" centres. Between centres 24". 8-speed all-geared head. 1½ h.p. motor. Available with extras such as quick change gearbox with 36 speeds and feeds and bed to admit 40" centres.
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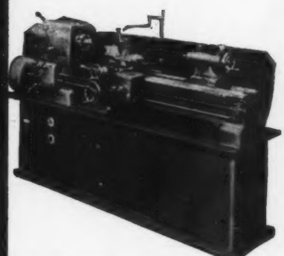

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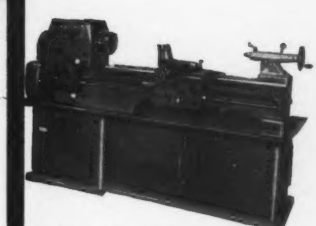

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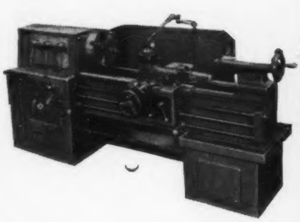

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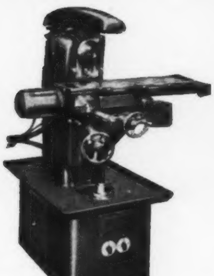

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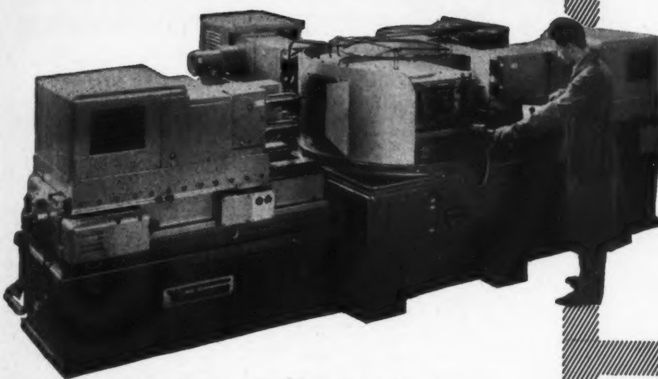

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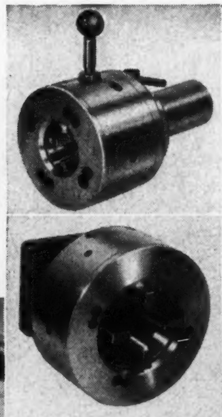

the world's finest threading equipment —

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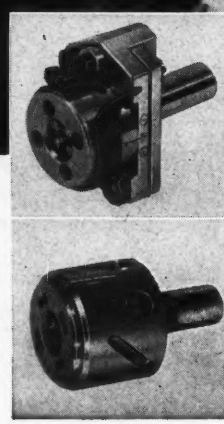

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1500 sizes and types of dies for cutting from commercial to precision threads, from the finest to coarsest pitch, standard or special forms, in all materials that can be threaded.

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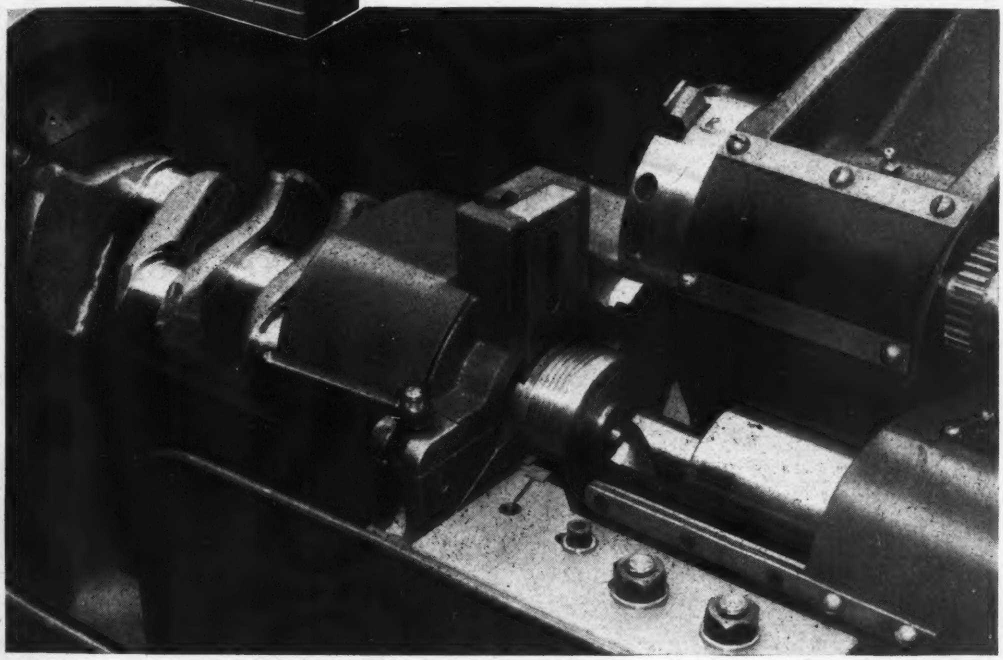
Simultaneous high-speed threading, facing and forming on crankshafts



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Precision threads are cut in a fraction of the time taken on a thread miller or centre lathe. Capable of cutting external or internal, parallel or taper, right or left-hand, single or multi-start threads in all forms and in any material that can be threaded.
Over 500 of these machines have been installed in customers' works since 1948.
Cut threads up to 5 T.P.I. in mild steel on 4in. external and 6in. internal diameters.

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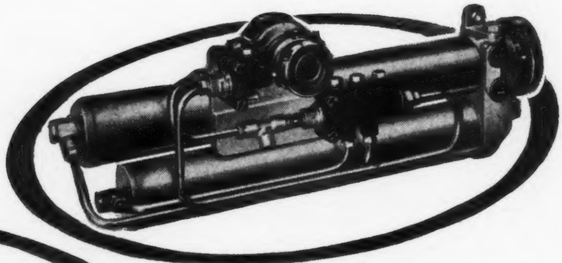

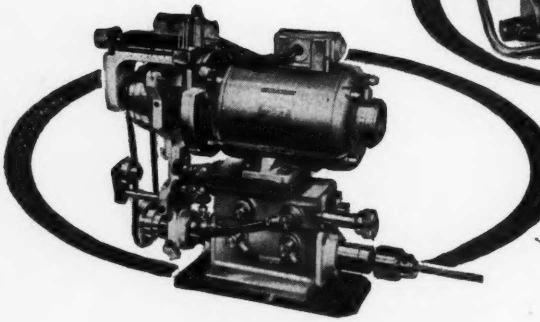

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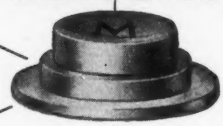
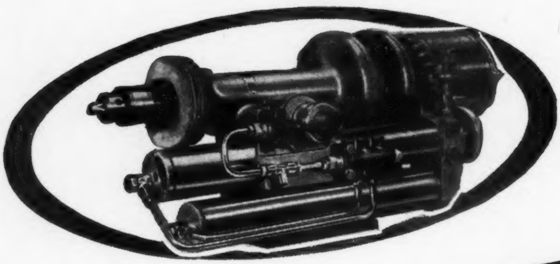
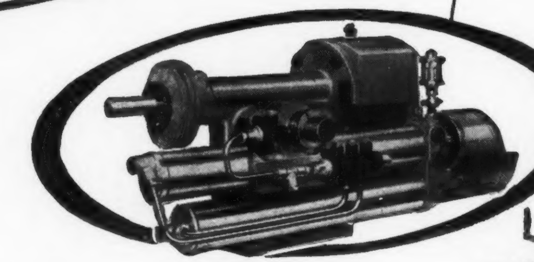
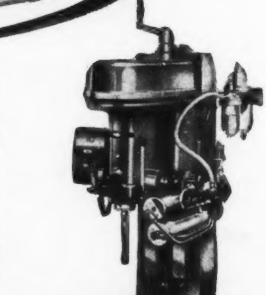




MEDDINGS *Pacera*





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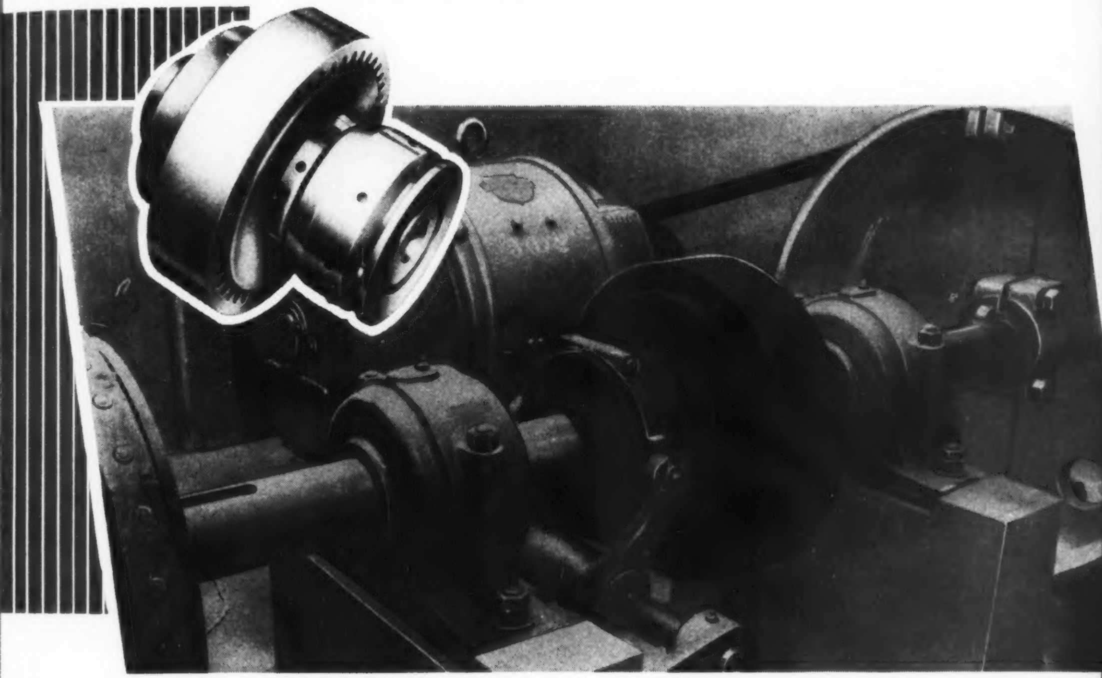

Controlling fibre board bonding and cutting machinery, here, a Crofts 14in. "RO" type Friction Clutch is seen as a wholly dependable servant to a modern industry.

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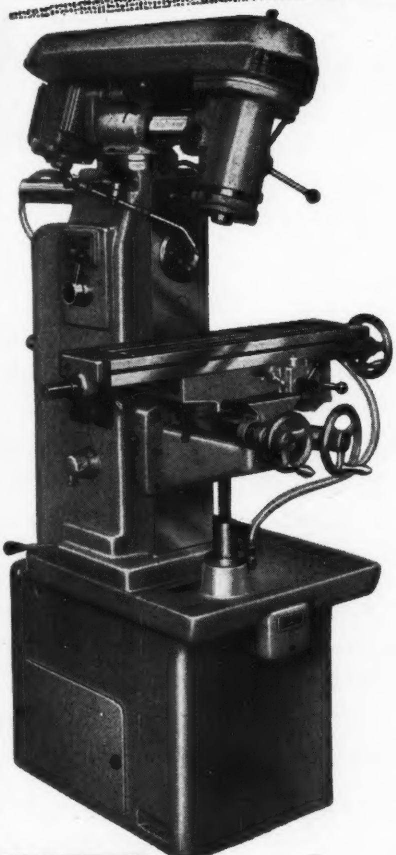

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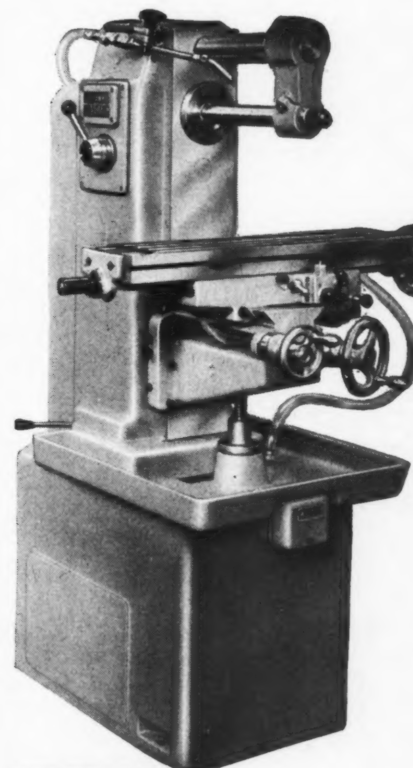
- Ideally suited to small jig, tool, die and fixture work.
- 7 Vertical spindle speeds 200 - 3,600 r.p.m. Vertical head motor $\frac{3}{4}$ h.p.



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- Especially designed for economical and accurate milling of small components.
- Table size 28" x 7".

On Both Machines

- 8 horizontal spindle speeds 100-1700 r.p.m.
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- Working surface 28" x 7".
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Optical measuring equipment, dividing heads, slotting attachment and universal attachment available as extra equipment.

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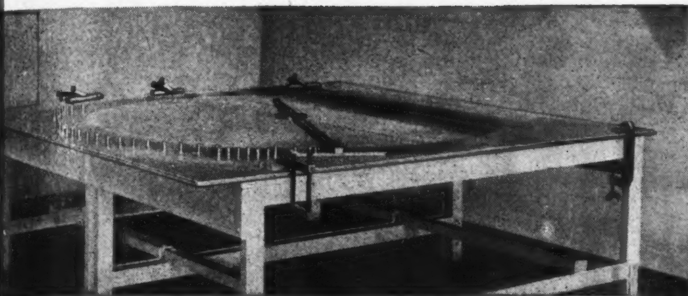
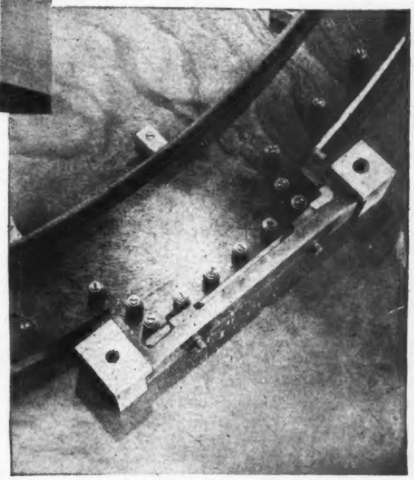
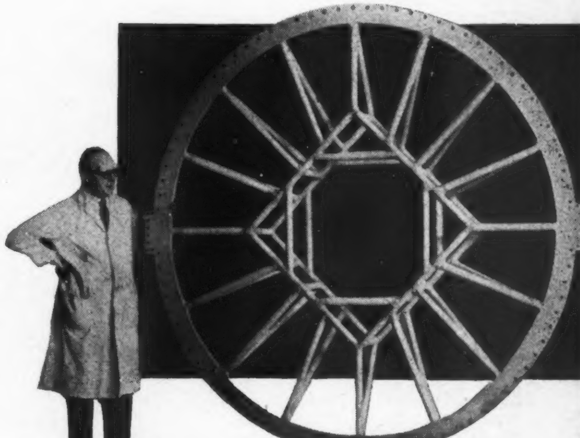




8 ft. DIAMETER DRILL JIG PRODUCED AT ONE-THIRD COST AND ONE-SIXTH WEIGHT OF CONVENTIONAL STEEL JIG

The illustrations show some of the stages of fabrication. A drill bush location plate is spigoted to the prepared working surface-bushes and metal inserts are positioned and fixed with wood screws and the 'dam' is built up—after fabricating the main ring the final step is to cement in the structural members.



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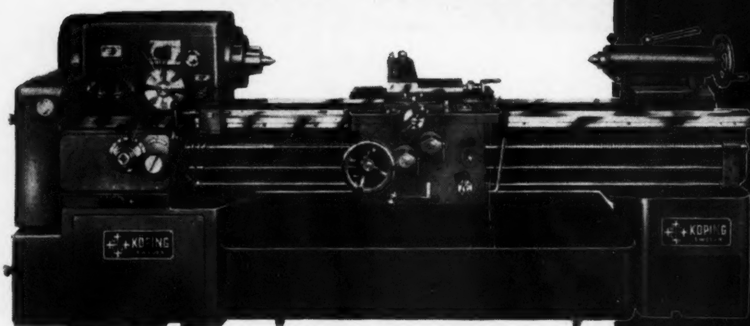
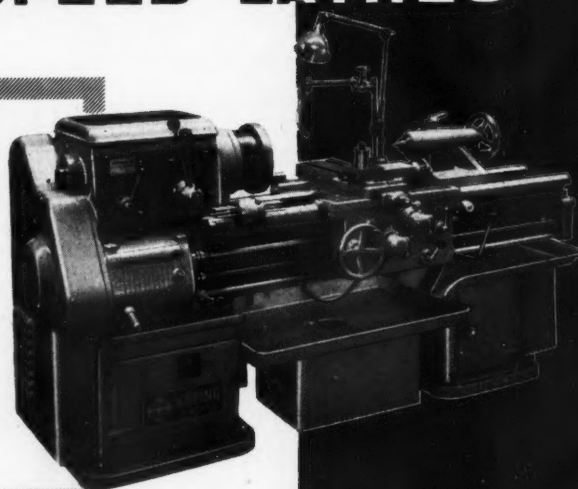


HIGH SPEED LATHES



S8C Model S8C High Speed High Precision Heavy Duty Lathe, 18 spindle speeds, 40 to 2,000 r.p.m. Frame hardened bed totally enclosed feed box and apron, 20 h.p.

S8S Köping S8S High Speed Lathe, 18 spindle speeds 12.5 to 1,000 r.p.m. straight or gap bed. All Köping Lathes are of the highest quality built to last a life-time.

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Weight 1,876 lbs.

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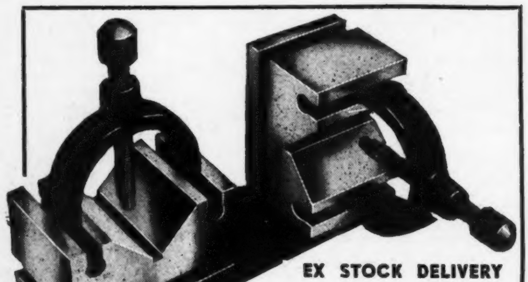

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Note: No. 2 SIZE HAS TWO VEES
THE FINEST BRITISH MADE STEEL VEE BLOCKS

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$2\frac{1}{2}'' \times 1\frac{5}{8}''$
£6 . 15 . 0
per pair

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CAP $2\frac{1}{8}''$
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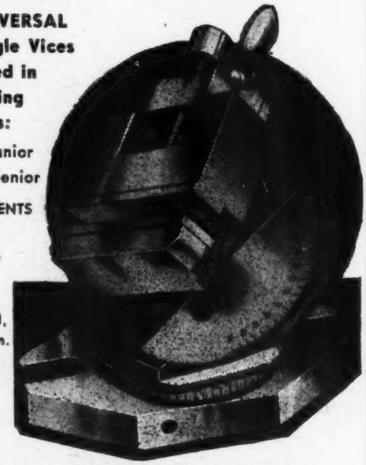

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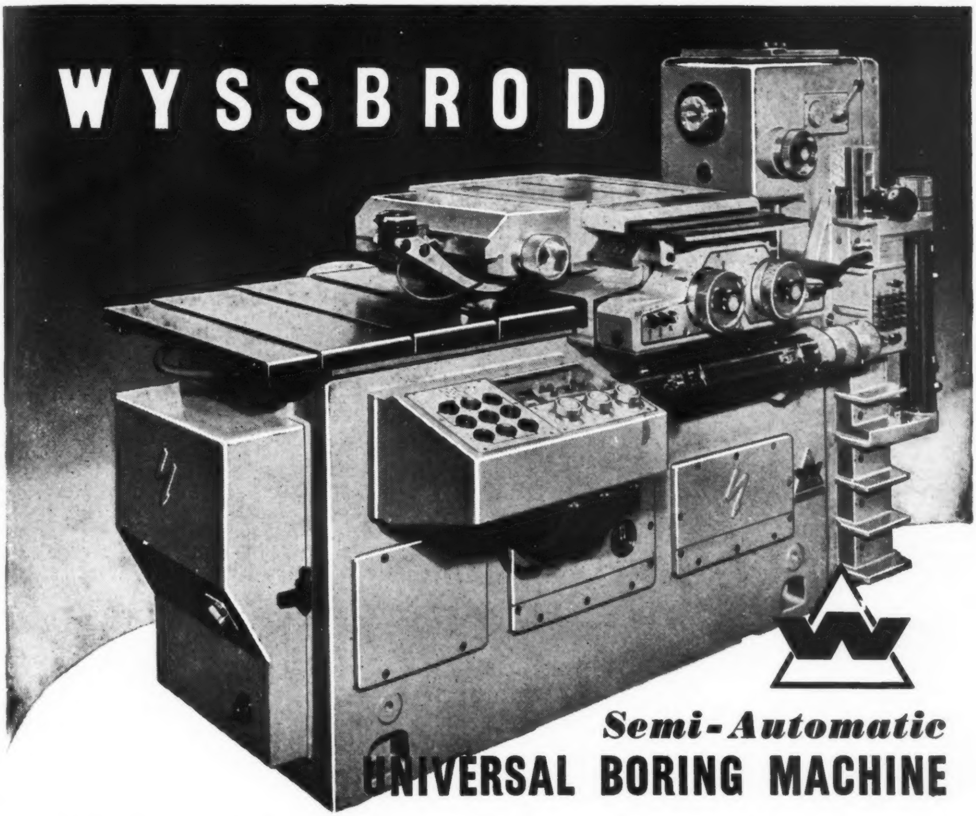

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- **Electro-hydraulic control**
- **Optical readings to 0.0004"**
- **Light precision milling if required**
- **Rotary table 16" x 16" optional**

Brief specification :-	**Model B57**
Dimensions of table	26" x 20"
Longitudinal stroke	20"
Transverse stroke	12"
Vertical stroke	12"
Feeds (stepless) ins/min.	2–11¾
Spindle speeds, r.p.m. (16 steps)	48–4000

This hydraulically-operated machine, built by an old-established Swiss company to traditional Swiss standards of precision, is an economical production jig borer suitable for "one-off" or series production, without the need for costly jigs and fixtures.

Its system of repeat co-ordinate setting, allied to robust construction, ensures consistent positional accuracy to 0.0004". The table and headstock clamp and unclamp automatically, but can be released for milling operations, and the spindle speeds can be changed automatically if required.

Outstanding features are hydraulic power to the table and headstock ; stepless feeds ; wide range of spindle speeds ; manual fine adjustment ; optical scales, and centralised controls.

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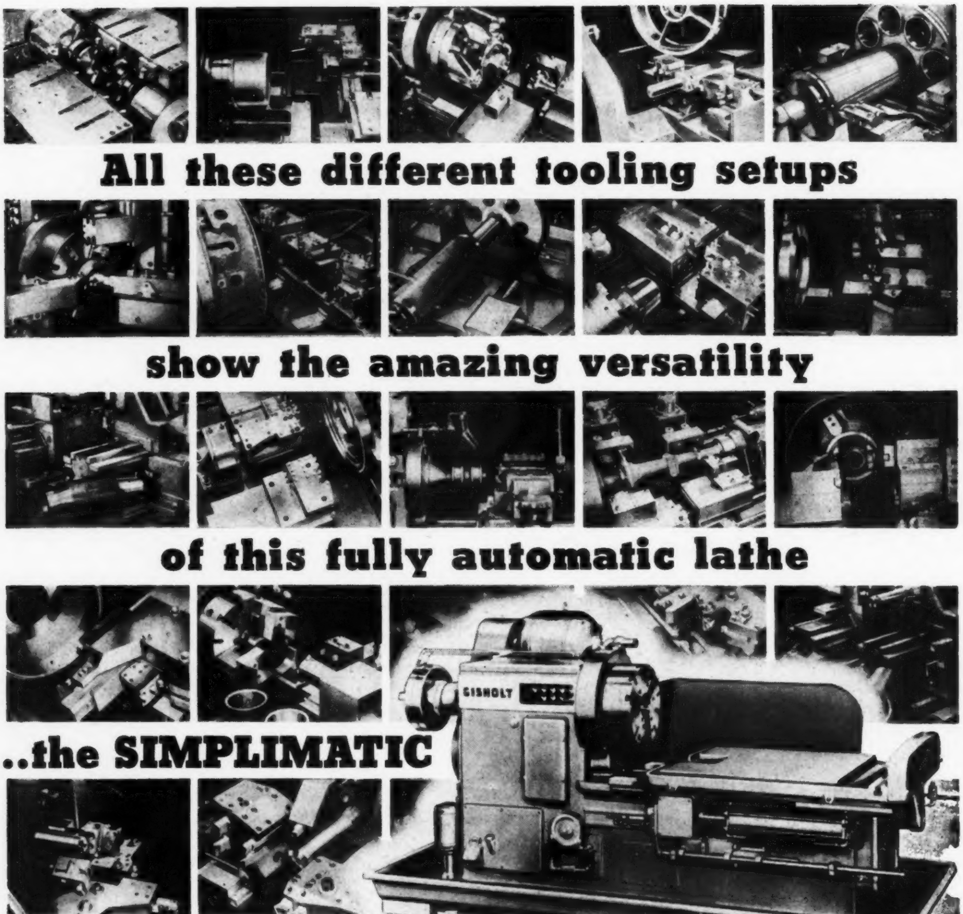

All these different tooling setups show the amazing versatility of this fully automatic lathe ..the SIMPLIMATIC

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If you have medium or long runs on parts up to 33½" in diameter, get the facts about the Simplimatic Automatic Lathe.

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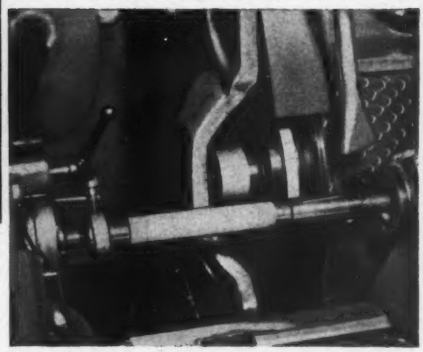

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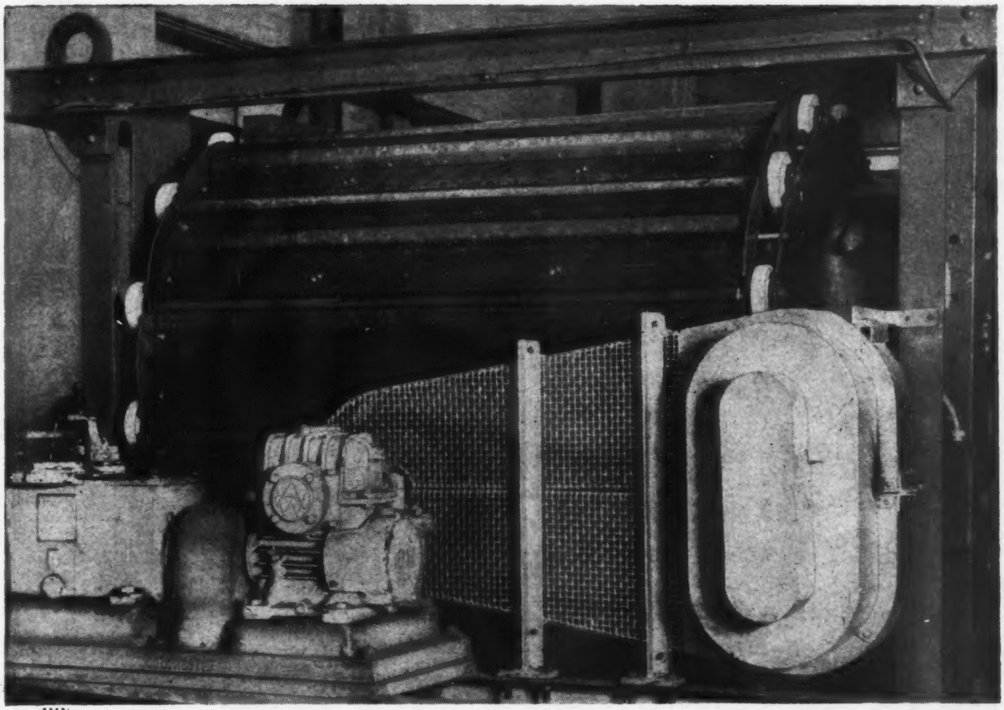
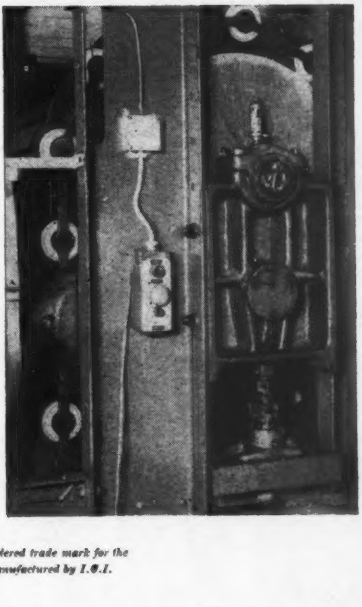


Rollers moulded from 'Maranyl' I.C.I. nylon by Punfield and Barstow (Mouldings) Limited, Westmoreland Road, Queensbury, London N.W.9, in central flow travelling band screens made by F. W. Brackett & Co. Ltd., Hythe Bridge Ironworks, Colchester, for the Central Electricity Generating Board, Uskmouth Power Station.



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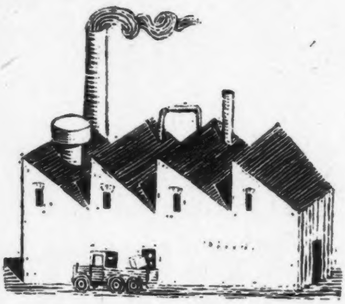

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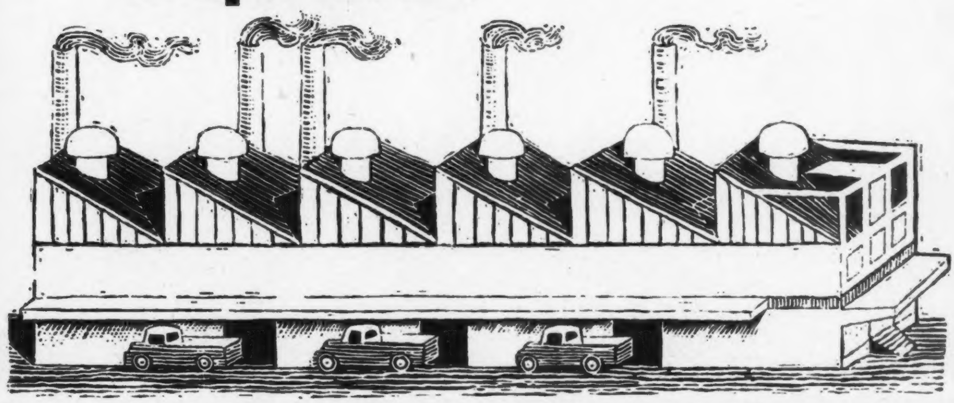

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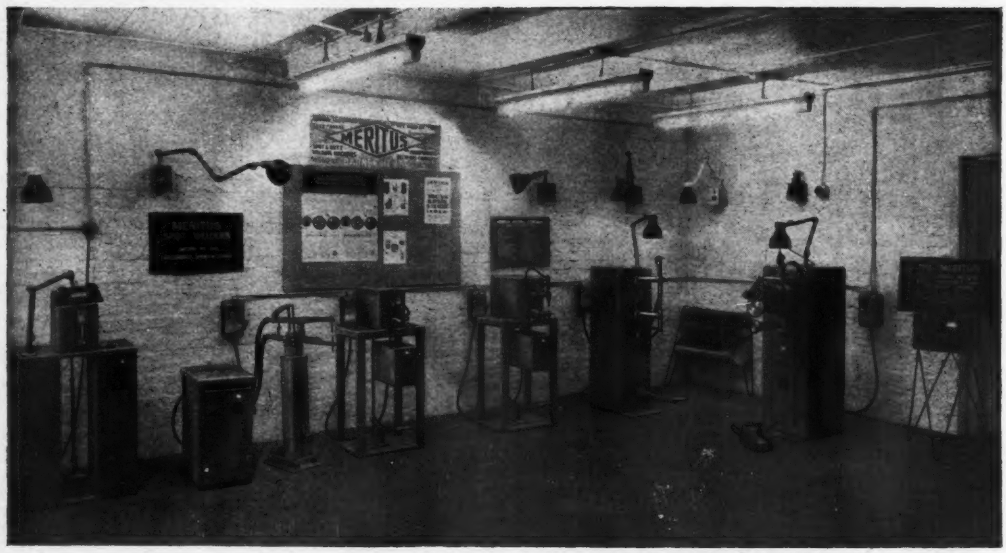

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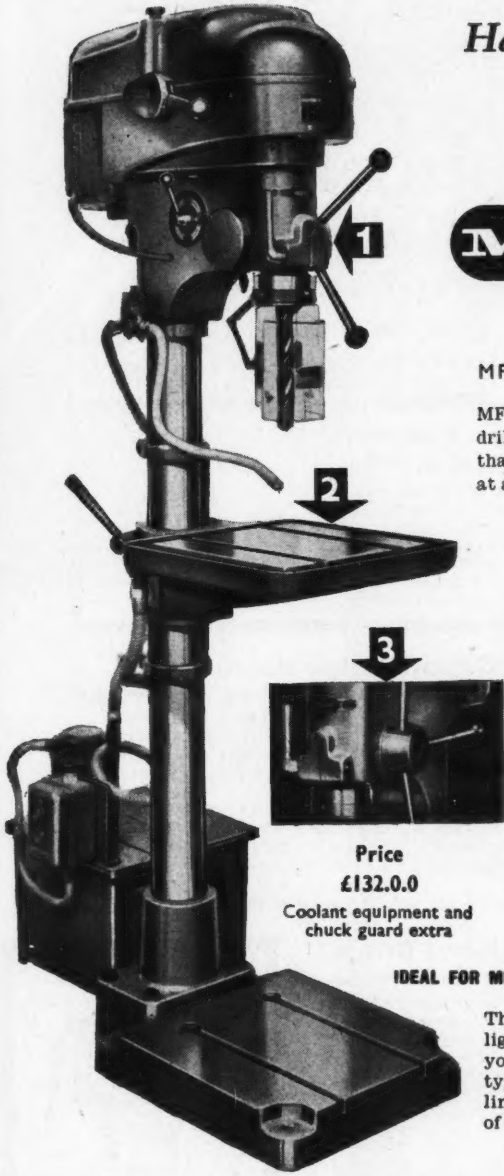

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Solid construction throughout means you've got real stability. The column is solid steel, 3½" diameter, and is ground all over. An oil immersed gearbox, totally enclosed in the Drill Head, gives eight spindle speeds (range 80-1,500 r.p.m.). Throat depth 9". Choice of High or Low speed setting for each of four Vee belt positions, thanks to accessible gear change lever with positive action.

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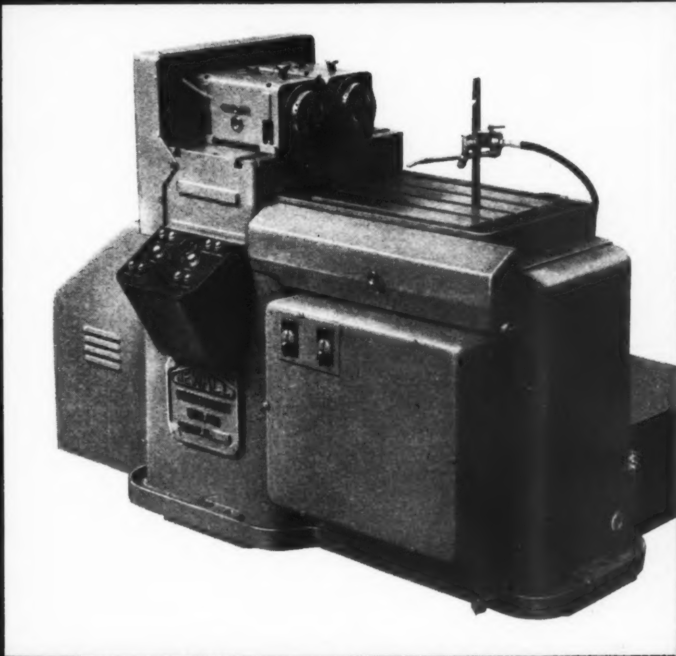

for increased productivity

Proved for reliability and highly economical production this machine, hydraulically operated through solenoid valves, is designed for high speed boring to close tolerances of a wide variety of components. With either single or double heads tooled to requirement, the machine can also be equipped with a hydraulically operated cross slide incorporating positioning stops for precise location.

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Table surface	$15\frac{3}{4}''$ x $22\frac{3}{4}''$
Table traverse	13″
Table feeds steplessly variable	$\frac{1}{4}$ to 16 ins/min.
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Weight (approx.)	6,160 lbs.

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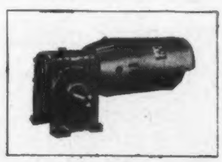

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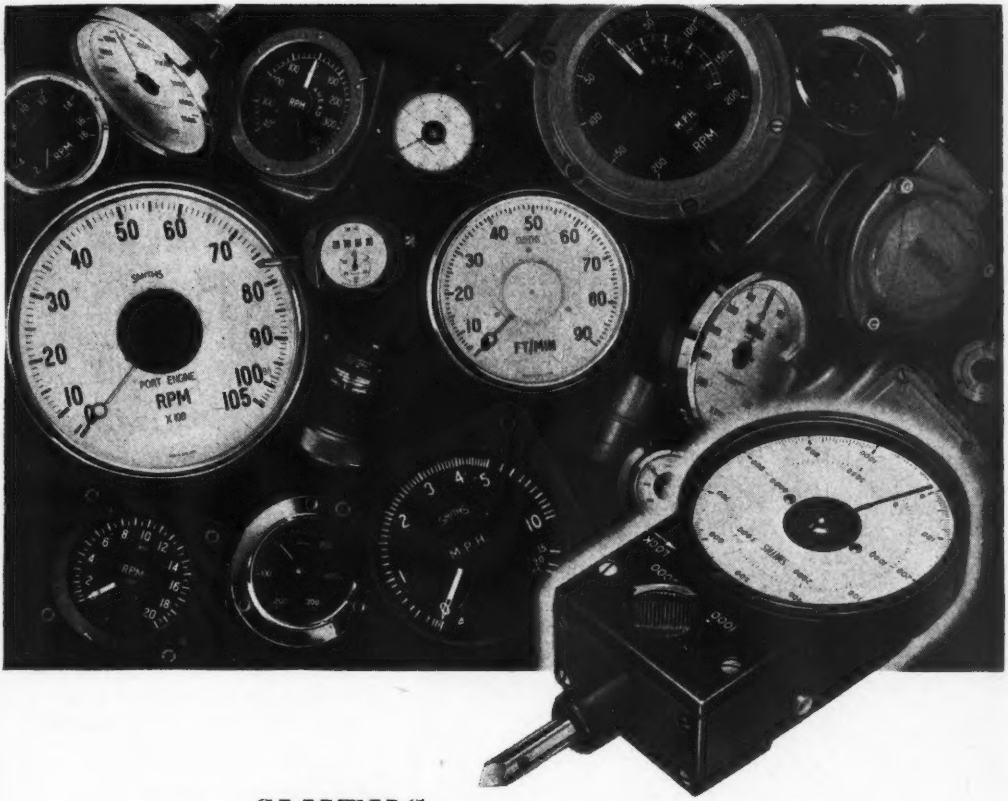
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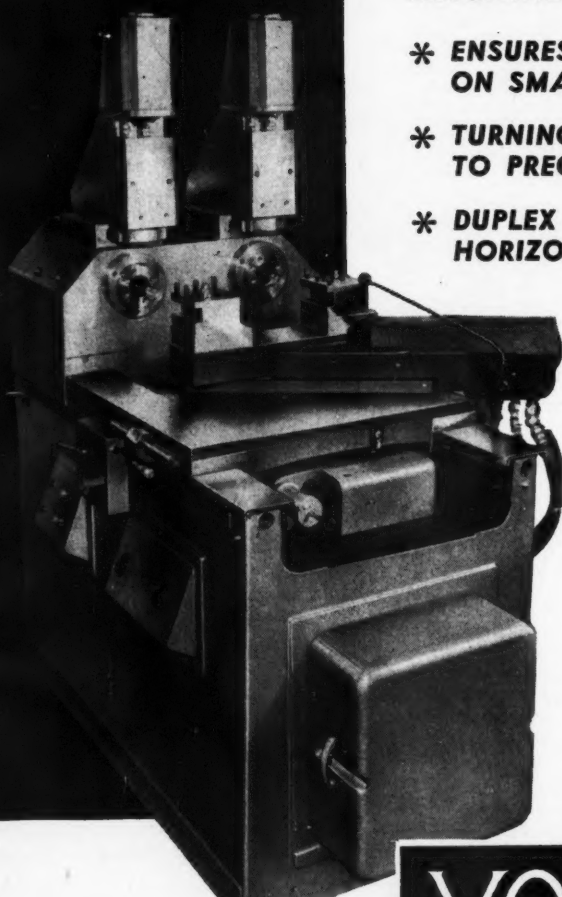

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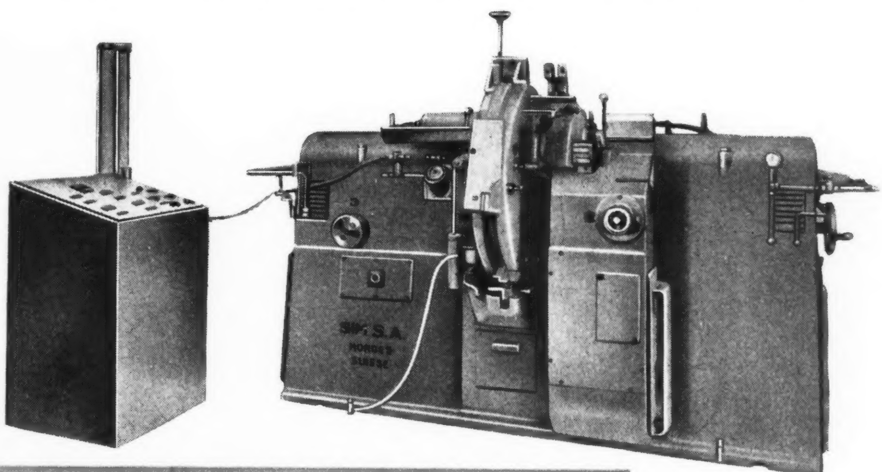

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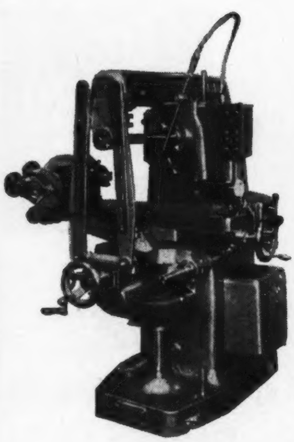

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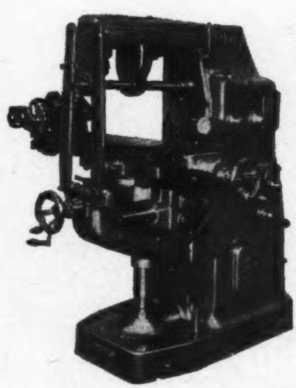

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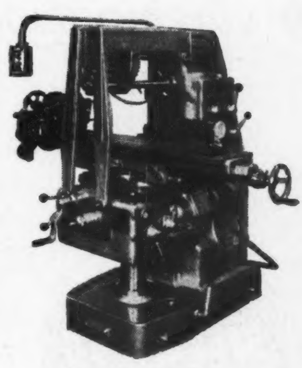

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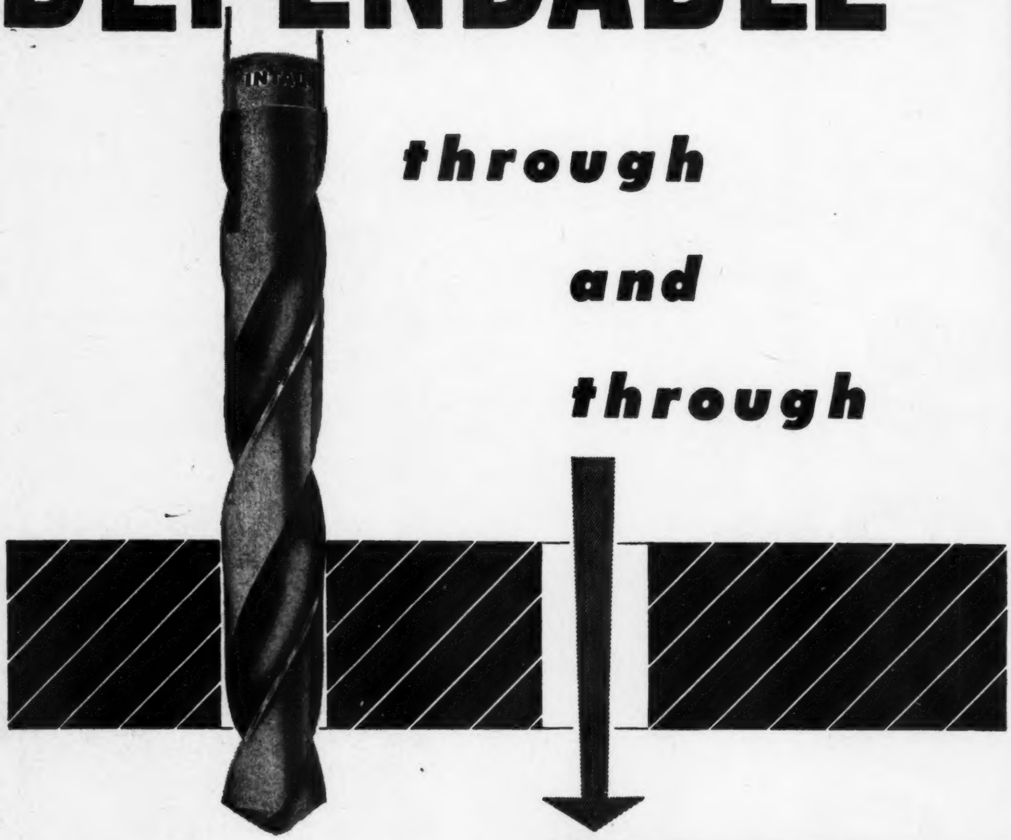

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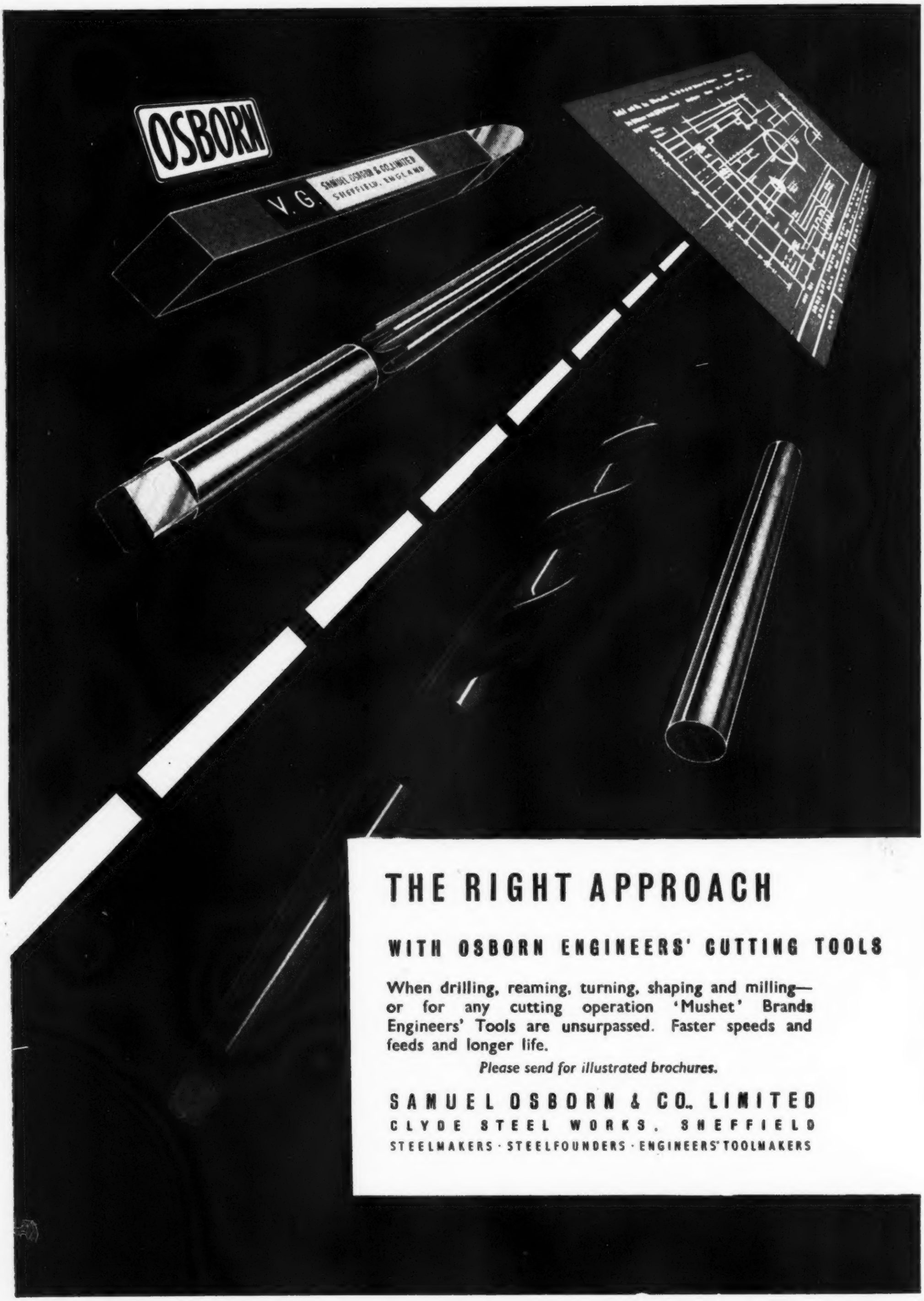
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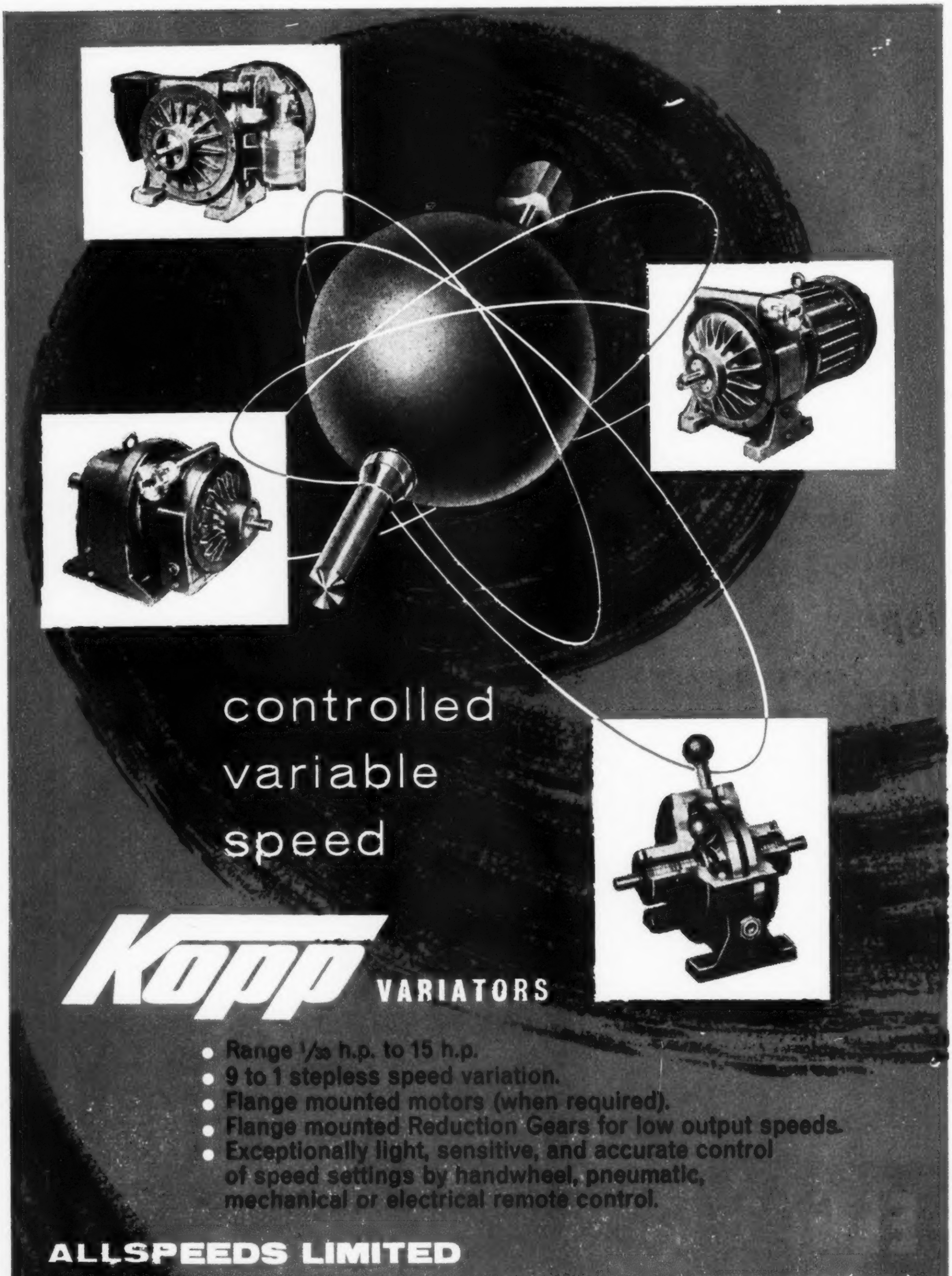

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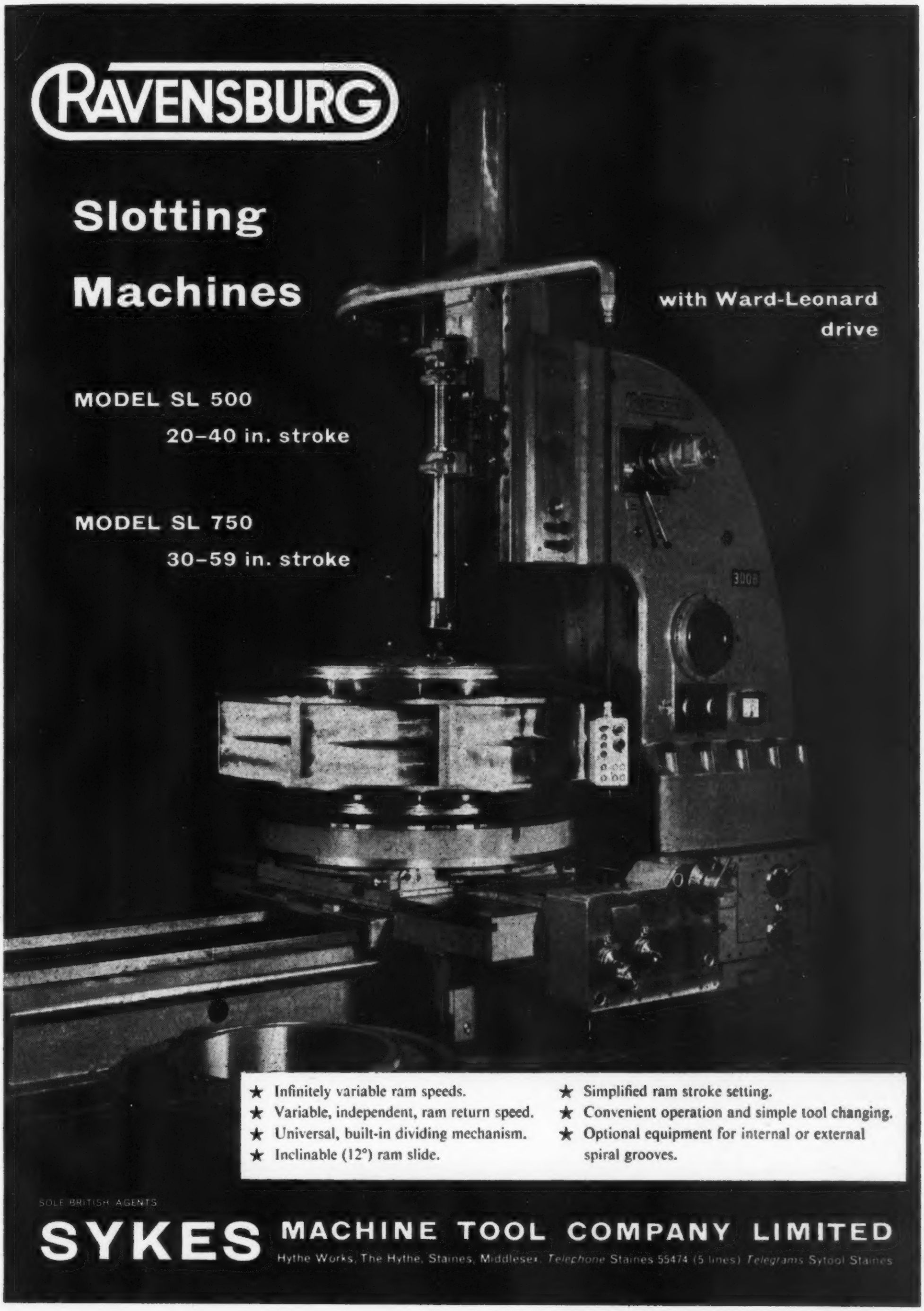
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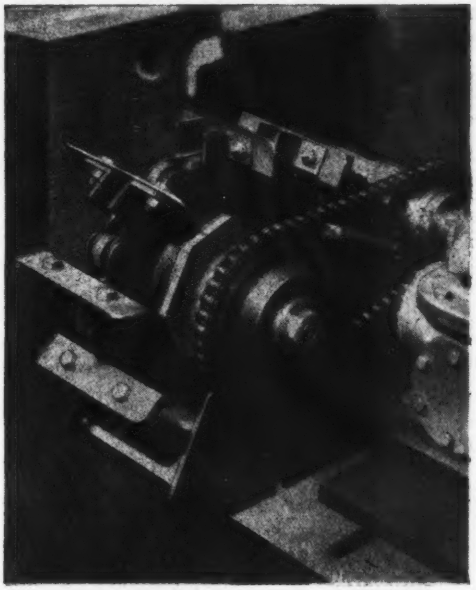

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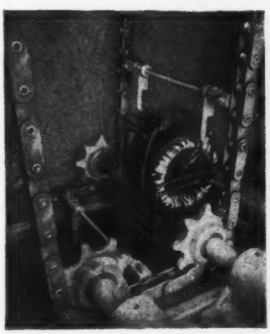

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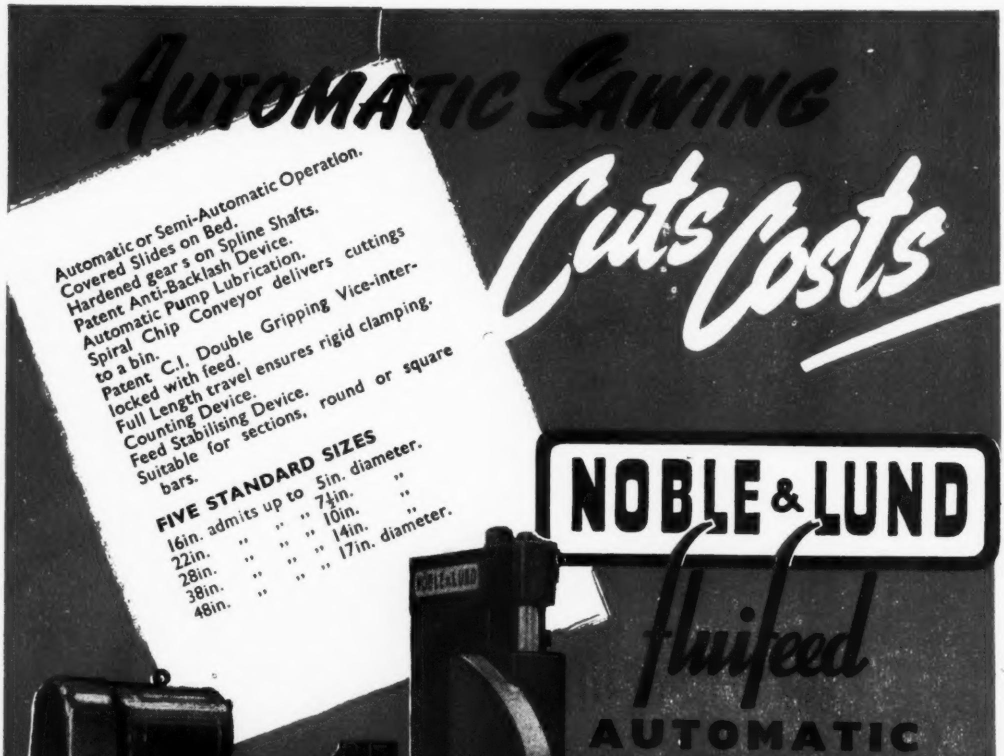
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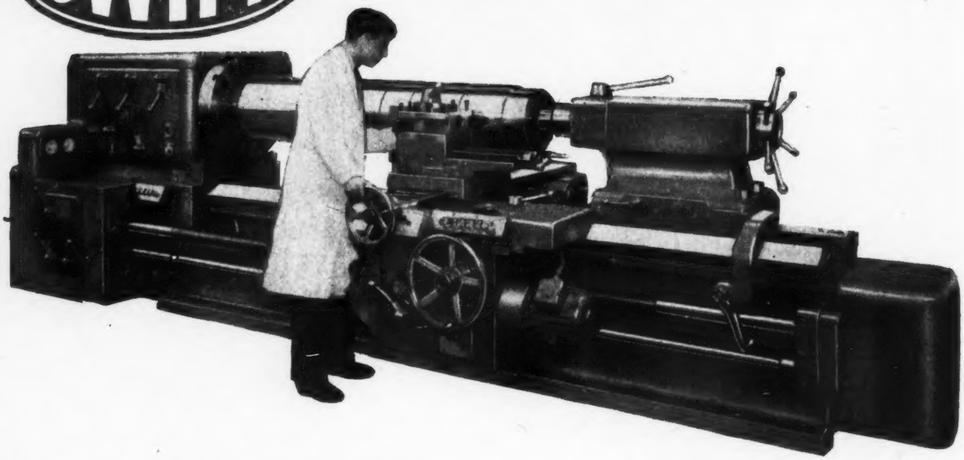

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Abstracts of Principal Articles

The SIP Type CLP-10 Photo-electric Longitudinal Comparator .. .. P. 944

Developed by Société Genevoise d'Instruments de Physique, the type CLP-10 photo-electric comparator represents an outstanding advance in the field of engineering metrology. Designed to implement the recent decision of the International Bureau of Weights and Measures that the metre should henceforth be defined in terms of wave-lengths of krypton 86, the equipment provides for measuring and comparing line standard and end standards, and incorporates photo-electric microscopes of the most advanced design. Interferometry equipment of the Michelson and Fabry-Perot types is also employed, and a significant advance has been made by the development of means whereby fringes can be detected and measured photo-electrically. From the mechanical standpoint, the design requirements presented formidable problems, and a number of interesting examples of unusual solutions are described. The main members of the comparator are arranged to be in "static balance" and no restraining connections are employed, thereby eliminating possible sources of stress and deflection. The environmental conditions in which the equipment is installed are obviously of vital importance, and impressive and complex precautions are taken to control and to measure such factors. (MACHINERY, 99—25/10/61.)

Alfred Herbert, Ltd., Head Works, Coventry P. 963

This article, the first in a series on machine tool building in Britain, traces the growth of the Alfred Herbert organization. Reference is made to the layout of the Head Works, Edgwick, Coventry, and representative examples of the machines installed are illustrated and briefly described. (MACHINERY, 99—25/10/61.)

Wickman Lo-Ten Blades for Face Milling P. 970

Recently introduced by Wickman, Ltd., Banner Lane, Coventry, Lo-Ten cutter blades are particularly intended for face milling operations on low tensile steels, but may also be used to advantage for machining certain types of high-tensile steels. Tests have been carried out to determine and compare the tangential, radial and feed force components when using three different types of blades, namely Wickman Hi-Ten, Lo-Ten and "special," and it is significant that the Lo-Ten blades resulted in extremely small radial forces as compared with the other types of blades. The blades are also particularly suitable for machining components which are prone to vibration under cut, and a typical example is given of this type of application. (MACHINERY, 99—25/10/61.)

An Incentive Wages Payment Scheme P. 972

In this article details are given of an incentive wages payment scheme which has been introduced at the Ipswich works of Ransomes, Sims & Jefferies, Ltd. Introduced originally for direct production workers only, the scheme has proved so successful that—at the request of representatives of various Trades Unions with members in the plant—it has been extended to cover indirect workers. The scheme is simple to operate, and is claimed to provide an incentive which is absent from conventional piece-work payment systems. (MACHINERY, 99—25/10/61).

Polygram 6-station Shell Mould and Core-making Machine .. .. .. P. 975

Designed to take advantage of a self-contained manipulator unit which has been introduced recently by the company, the 6-station shell mould and core-making machine here described has been built by Polygram Casting Co., Ltd., Shernfold Park, Frant, Tunbridge Wells, Kent. The machine is of the rotary-transfer type and is supervised by two men, and with single-impression boxes it is stated that 100 cores per hour are produced. A blowing head introduces the sand, and each manipulator complete with pattern or core box is indexed beneath this unit successively. Electrical heaters are incorporated for curing the moulds or cores. (MACHINERY, 99—25/10/61.)

Gating of Aluminium Die Casting Dies P. 977

In this article, which is the second of two, the general principles underlying effective gating are first discussed, and then reference is made to the provision of gates for a long narrow casting. Filling of the cavity for such a casting is considered in some detail, and the possible gating arrangements are discussed, and reference is made to the use of overflows. Requirements for thinner castings and the effects of core displacement are also considered, and reference is made to the gating of rectangular frames, annular castings and dish and cup-shaped parts. Finally, some general requirements for effective gating are discussed. (MACHINERY, 99—25/10/61.)

Contributions to MACHINERY

If you know of a more efficient way of designing a tool, gauge, fixture, or mechanism, machining or forming a metal component, heat treating, plating or enamelling, handling parts or material, building up an assembly, utilizing supplies, or laying out or organizing a department or a factory, send it to the Editor. Short comments upon published articles and letters on subjects concerning the metal-working industries are particularly welcome. Payment will be made for exclusive contributions.

EDITORIAL

Scientific Manpower—Supply and Demand

Last year, the Committee on Scientific Manpower of the Advisory Council on Scientific Policy reviewed preliminary estimates of the supply of scientists and technologists expected to result if the university population were raised to 170,000 by 1971, and if, in addition, projected increases in the output of qualified manpower from colleges of advanced technology and similar institutions were achieved. At the same time, the Statistics Committee of the Council was invited "to review the long-term demand up to about 1970, considering separately scientists and technologists, and distinguishing as far as practicable between the various disciplines." A report on "The Long-term Demand for Scientific Manpower"* has now been issued, in which the findings are presented and reviewed, and is noteworthy on account of the rapid change in the general situation which is forecast.

In the academic year 1958-59, it is pointed out, the output of qualified scientists and technologists was 14,300, of whom 7,600 came from universities and 6,700 from technical colleges, and of that total, scientists accounted for 6,000 and technologists for 8,200. By 1965-66, it is anticipated, the overall figure will have risen to 21,600—an increase of slightly more than 50 per cent as compared with the datum year. According to the estimate, the universities will account for 11,800 (in 1965-66) and the technical colleges for 9,800, and the total will comprise 9,400 scientists and 12,200 technologists. Looking further ahead, it is believed that by 1970-71 the output will have expanded to 27,500 (15,500 from universities and 12,000 from technical colleges) and will include 12,700 scientists and 14,800 technologists. The full effects of the planned increases in numbers of students at universities and colleges of advanced technology, however, will not be felt until 1973-74 when the total output is expected to reach 31,600 (15,000 scientists and 16,600 technologists).

It is undoubtedly more difficult to determine probable future requirements for scientific manpower than to assess potential supplies, but it is evident that the Statistics Committee have been to great pains to achieve the most reliable estimates possible in the circumstances, and the various assumptions that have necessarily been made are clearly set out. As a result of these investigations it is predicted that overall demand and supply will be approximately in balance by 1965, with some surplus of scientists (107,700 estimated to be available as compared with a demand for 104,500) and some deficiency of technologists (estimated supply and demand, 147,300 and 150,000 respectively). By 1970, moreover, it is thought that there will be a surplus of the order of 5 per cent for both groups.

Commenting on these findings, the Committee on Scientific Manpower point out that the possibility of an approximate balance being reached as early as 1965 "will come as a surprise when one considers the crippling shortages of scientific manpower that have been experienced since the war." They add, however, that supply and demand in individual branches cannot be so easily equated and that "there may well be important differences in the factors which govern employment prospects between the specialized technologist and the engineer with a general training, and between engineers as a group and scientists."

In this connection, it is appropriate to refer to the remarks on the subject made by Mr. Harold Burke, M.I.Mech.E., M.I.Prod.E., F.B.I.M., President of the Institution of Production Engineers, in his enlightened message to members which appeared in the October issue of *The Production Engineer*. It was essential, he said, that production engineering should be established as a primary technology and that "facilities for training production engineers at the various colleges of advanced technology throughout the country should be built up as rapidly as possible." He also drew attention to the need "to increase substantially the facilities available to permit of a far larger number of university entrants," and to this end, he advocated that provision should be made for production engineering studies at additional universities throughout the country, and particularly at "the six new universities now being planned by the Government."

The Committee on Scientific Manpower welcome the possibility of a surplus of scientists over immediate "demands for employment" because it should make possible "a rational, as opposed to an emergency, use of the scientific disciplines. It should mean that at long last we should have a supply of qualified manpower with a scientific training for management, administration, and the professions generally, in addition to those who up to the present have been drawn inevitably into

(*Continued on page* 999)

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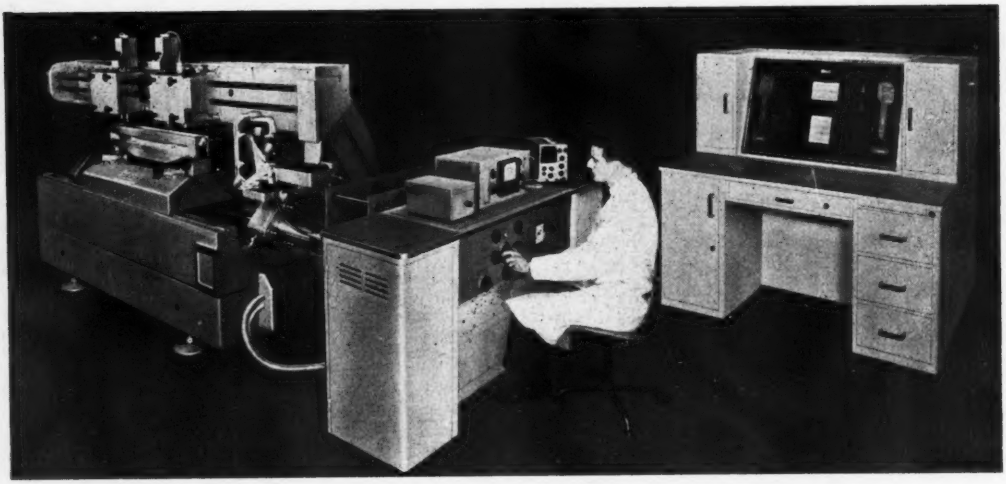


The SIP Type CLP-10 Photo-electric Longitudinal Comparator

Details of New Length-measuring and Comparing Equipment of Outstanding Accuracy and Design Interest which has Recently been Developed by the Société Genevoise d'Instruments de Physique, Geneva, Switzerland

By A. W. ASTROP, Associate Editor

FOR MORE THAN 70 YEARS, the length of the metre was defined legally as the distance between the axes of two lines on a 90/10 platinum-iridium bar, this distance being measured at the temperature of melting ice (0 deg. C.). This definition was agreed at the International Conference on Weights and Measures which was held in 1889, and of the thirty similar bars which were produced at that time, and as a result of the decision, one was selected and adopted as the international master. It is stored, with three similar bars, in a small cellar of the premises of the International Bureau of Weights and Measures at Sèvres, France.

With the necessary control of environment, the equipment here described offers the possibilities of measuring and comparing lengths with an accuracy that has never before been achieved. Its existence will therefore make a vital contribution to future progress in all branches of precision engineering throughout the world

In 1954, however, the proposition that the length of the metre be defined in terms of wave-lengths of light was reconsidered, because of the desirability of utilizing a natural phenomenon which is unalterable, and to all intents and purposes is capable of being reproduced consistently at all times and in all places. As a result, the National Committee of Weights and Measures decided to recommend that the wave-length definition be ratified by the XIth General Conference on Weights and Measures, that was to be held in October, 1960. At this conference, a resolution was proposed and adopted to the effect that the metre should henceforth be defined as a length equal to 1,650,763·73 wave-lengths of a selected spectral

line emitted by the isotope krypton 86. This wave-length is 0·6057 μm.

It is obvious that this decision was of the utmost significance, and that its implications are far-reaching. One of the first requirements was equipment whereby the new standard could be implemented, namely apparatus capable of measuring, and comparing, the more practical forms of length standard in terms of the new wave-length standard. A fundamental principle on which the design of such equipment could be based was put forward by M. Volet, Director of the International Bureau of Weights and Measures, and this body subsequently studied and accepted a design for a practical application which had been prepared by the Société Genevoise d'Instruments de Physique, Geneva, Switzerland. The decision to build such equipment was ratified by the International Committee of Weights and Measures, and during all stages of the subsequent detailed design and development, the company worked in the closest collaboration with M. J. Terrien, Deputy Director of the B.I.P.M.

The apparatus, a general view of which is given in the heading illustration, is known as the SIP type CLP-10 photo-electric longitudinal comparator, and combines interferometry equipment—of the Michelson and Fabry-Perot types—with a line standard comparator arrangement incorporating two photo-electric microscopes. It is intended for three main applications, in addition to the original purpose of very accurate measurement of line standards in terms of wave-lengths. It will compare line standards up to 1 metre long with end standards of the same dimensions, by interferometry; compare the full lengths of two line standards, from 0·1 to 1 metre long, without the use of interferometry; and compare the sub-divisions of two line standards up to 1 metre long, without the use of interferometry.

The first comparator of this type to be built by the company has already been despatched to the B.I.P.M. at Sèvres, and at the time of writing its installation is virtually complete. It will be appreciated that special premises are required to house the equipment, with provision for the most meticulous control and measurement of environmental conditions, such as temperature, humidity and pressure, and precautions must be taken to ensure that vibration, from whatever source, is virtually eliminated, since such phenomena can very severely affect the interferometry equipment. The comparator itself is enclosed in a massive air-tight cylinder, outside which the temperature of the surrounding air will be controlled to well within 0·1 deg. C. As a result of what may be termed the "thermal inertia" of the air-tight cylinder, it is anticipated that the temperature of the apparatus which is enclosed will be maintained to an accuracy of the order of ±0·001 deg. C. Temperature control is obviously of primary importance to avoid linear variations of the apparatus, and of the standards being measured or compared, but control of other environmental factors is of equal significance.

For example, the wave-lengths are affected by the humidity, the atmospheric pressure and the composition of the air within the cylinder. The refractive index of the air is also dependent on the temperature, and must furthermore be compared accurately with that of a vacuum, in relation to which the new wave-length standard is defined. The air-tight cylinder is split horizontally along its longitudinal centre line, and provision is made for removing the upper half, by means of a crane, for installing and dismantling the comparator. A portion of the upper half is also removable, to provide access for the operator for setting-up purposes, for example. Once these operations have been completed, the removable portion is replaced, and sealed, and the operator retires to an adjacent control room which is heavily insulated from that containing the cylinder. In this room, equipment is installed whereby every function of the apparatus can be controlled remotely, and it may be mentioned that a simple form of closed-circuit television equipment is incorporated whereby the operator can check the surface of a line standard being measured or compared to ascertain whether any dust, for example, is present.

It is stated that Société Genevoise expended some 80,000 hours on research work in connection with the design and development of the apparatus for Sèvres, and at the time of our visit, a second similar comparator was in an advanced stage of construction for supply to the Federal Bureau of Weights and Measures, Berne, Switzerland. Work was also in hand to supply photo-electric microscopes of the type employed on the CLP-10 comparator to Ottawa, Canada.

Before proceeding to a more detailed description of the mechanical, electrical and optical design of the equipment, also of the special premises which are required, it is proposed to discuss the theoretical metrology on which it is based, since it is only in the light of an understanding of the basic principle that the exceptionally stringent design requirements can be appreciated.

THE BASIC PRINCIPLE AS PROPOSED BY M. VOLET

The basic principle for length measurement in terms of wave-lengths, as proposed by M. Volet, can best be explained diagrammatically, and with reference to the procedure for measuring the dis-

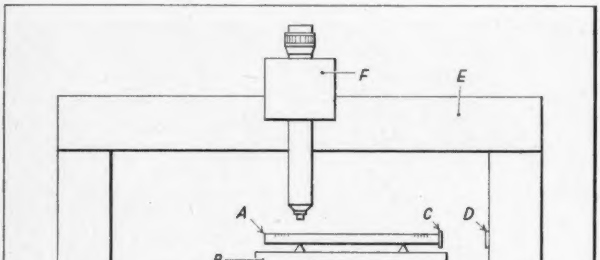


Fig. 1. Diagrammatic layout of the system proposed by M. Volet, Director of the International Bureau of Weights and Measures, Sèvres, Paris, for the measurement of line standards in terms of wave-lengths of light

tance between two lines on a line standard. Fundamentally, it involves the displacement of the line standard longitudinally by the distance between two graduations, the latter being accurately located with the aid of a photo-electric microscope, and of measuring the *actual* distance moved by an interferometry technique. The difference between the stated value for the distance between the two graduations and the reading obtained by interferometry represents the amount of error of the line standard.

The system is shown diagrammatically in Fig. 1, where a line standard being checked is indicated at *A*. Supported at the points which ensure the minimum shortening of overall length (Bessel points), the standard is mounted on a carriage *B*, which can be moved longitudinally. At the right-hand end of the line standard there is a mirror *C*, and there is another mirror *D* which is fixed to one pair of columns that support the beam *E*. On this beam there is a photo-electric microscope *F*. The mirrors *D* and *C* are the "fixed" and "moving" mirrors respectively of a Michelson-type interferometer, and initially the carriage *B* is moved longitudinally so that one of the graduations on the standard *A* is accurately aligned with the optical axis of the photo-electric microscope. An interferometric reading is then taken.

Next, the carriage is moved longitudinally to bring the other graduation on the standard beneath the microscope, and a second reading is taken from the interferometer. In principle, the system is extremely simple, but it will be appreciated that the difficulties associated with its practical application are formidable. In addition to the precise control of the environmental conditions already mentioned, it is also obviously essential that the distance between the optical axis of the microscope and the plane of the fixed mirror *D* must remain absolutely constant, and must not be affected either by temperature changes, or by deflections caused by the movement of the carriage. Furthermore, since the interferometry

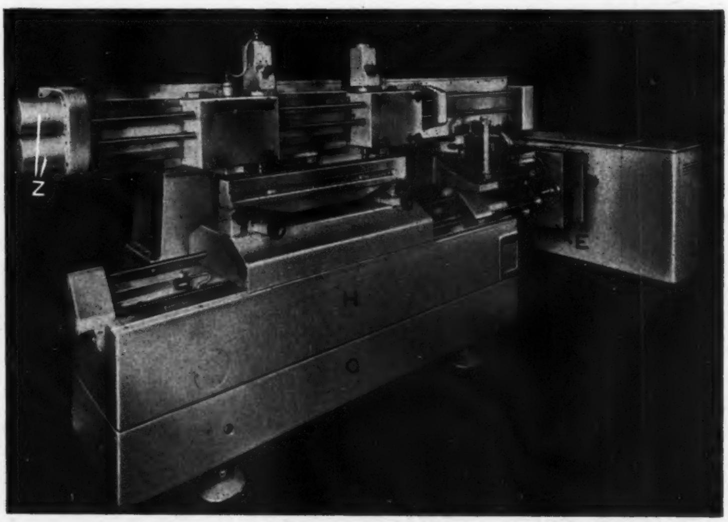


Fig. 2. General view of the SIP type CLP-10 photo-electric longitudinal comparator, which was built to implement the new wave-length standard

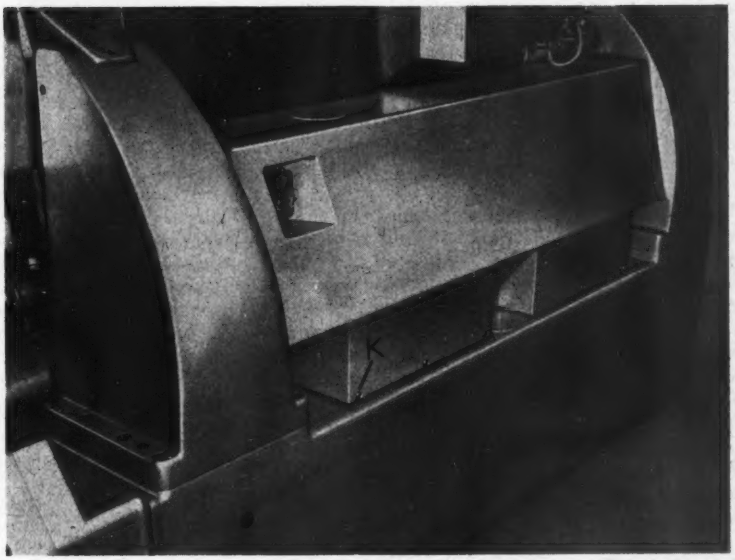


Fig. 3. Rear view of the type CLP-10 comparator, showing the column assembly which incorporates an integral tie beam

technique is of the utmost sensitivity, meticulous care must be taken to ensure that the planes of the mirrors *C* and *D* remain precisely parallel—at all positions of the carriage—and that vibration and instability of the apparatus are eliminated as far as possible. It is significant to note with regard to the longitudinal movement of the carriage *B*, for example, that slideways of the roller-type designed and made even to the impressively exacting standards of accuracy which are associated with Société Genevoise were inadequate for straightness and flatness. Any departure from straightness and flatness in the ways results in loss of parallelism between the fixed and moving mirrors, and consequently special provision is made for adjusting one of the supports for the line standard, in order to restore the required parallelism of the mirrors after the carriage has been traversed. Details of this feature will be included later in the article.

SOME FEATURES OF THE MECHANICAL DESIGN

One of the primary considerations in the design of the comparator was to ensure that movements of the carriage should not result in deflections of the main members, or disturb the positions of the photo-electric microscopes—of which there are two, as will be explained later. Referring to Fig. 2, which is a view of the complete comparator, it will be seen that there is a massive base member *G*. This base is supported kinematically at three points, by large-diameter pad-type mounting feet, two of which can be seen in the figure. The main portion of this base is of the same size as the bed member *H*, but at the rear it has a projecting area, of greater overall depth, which serves to support the twin column assembly.

The column assembly is of particular interest, and is shown clearly in Fig. 3, which is a view from the rear of the comparator that was under construction for the Federal Bureau of Weights and Measures at the time of our recent visit. It will be noted that the twin columns are cast integral with a massive " tie-bar," and that this latter portion has two large box-structures which project from the under-side. Each column has flanged feet, through which screws and dowels pass into the base member *G*, Fig. 2. Pads on the latter serve to hold two thick-section steel plates, and it is into the edges of these plates that the screws indicated at *K* in Fig. 3 pass. It has been found that this design of column assembly provides the high degree of rigidity and stability which is required.

The bed *H*, Fig. 2, on which the carriage is traversed, is " free-standing " on the front portion of the base member *G*, and is in no way connected to the column assembly. It is supported at three points which coincide precisely with the three feet which support the base *G*. This arrangement was adopted to ensure that compression forces only were present in the base *G*, as a result of the weight of the bed *H* and its carriage, to eliminate any bending or twisting which might tend to deflect the column assembly. The method of supporting the bed *H* at three points is of interest. Projecting from the under-side of this member there are three hardened steel balls, which engage with special seatings provided on the upper surface of the base. One seating takes the form of a conical depression,

another is a plain V-groove (which is arranged parallel to the longitudinal centre line of the base) and the third is a flat pad. With this arrangement, the bed *H* is supported kinematically at three points, and located longitudinally, transversely and angularly without the need for restraining connections, such as screws or dowels, which might introduce undesirable stresses. Provision is made in the mountings for levelling the bed *H*.

A similar form of mounting is employed for the cross-rail on which the photo-electric microscopes are arranged to slide. This rail is in effect "hung" from the column assembly and, once again, no restraining connections are employed. Projecting from the back of the cross-rail are two integrally-cast ears, one of which may be seen at the top left-hand corner of Fig. 3. These ears are arranged at the same centre distance as the columns and each is provided with a hardened steel ball which projects from the under-side. In the top face of one column there is a conical seating, and in the other there is a V-groove seating. The third support point is provided by a steel ball projecting from the back of the cross-rail which rests on a flat pad provided on the vertical front face of the left-hand column (as viewed in Fig. 3).

With the bed *H* and the cross-rail supported as described, it will be appreciated that all the main members of the comparator are in what may be termed "static equilibrium," and that inherent stresses originating from restraining systems have been completely eliminated. Any minute deflections of the bed *H* which are caused by movements of the carriage cannot be transmitted to the column assembly, since there are no direct connections between the two parts, and, in consequence, the cross-rail—and in particular the positions of the microscopes—are unaffected. The cross-rail is covered with a "skin" of ½-in. thick bright aluminium plate, which provides a heat-reflective surface to reduce the amount of heat absorbed by the rail.

THE TRAVERSING CARRIAGE

A close-up view of the traversing carriage is given in Fig. 4, where the microscopes can be

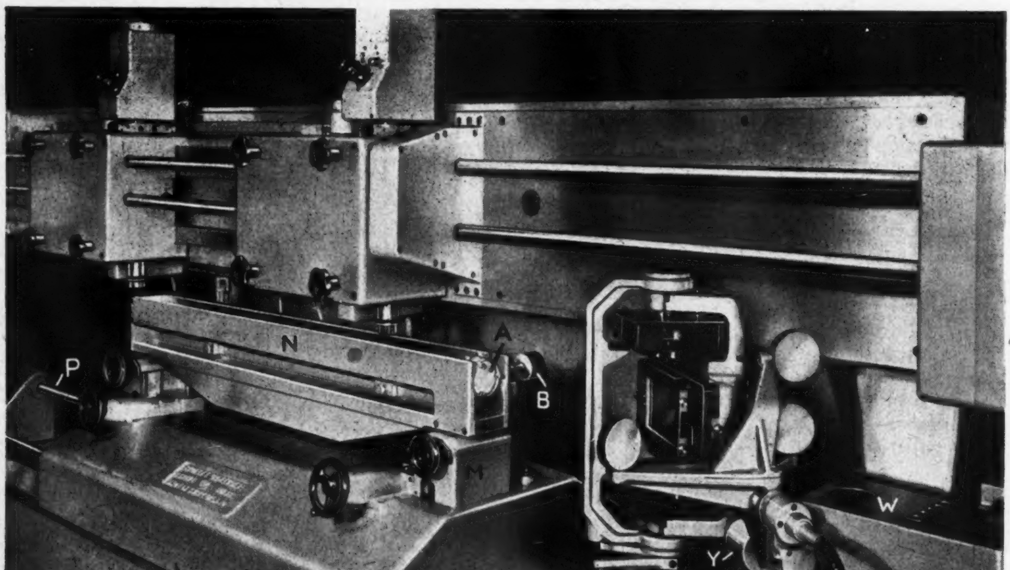


Fig. 4. Close-up view of the carriage which supports the line standard to be checked. The photo-electric microscopes and the Michelson interferometer can also be seen

seen, also the Michelson interferometer, at the right. Indicated at *L*, the carriage is provided with roller-type slides, as mentioned earlier, of the design similar to that employed on the company's Hydroptic range of jig boring machines. The front guideway in the bed *H* (Fig. 2) is of V-form, and houses crossed cylindrical rollers, whereas the rear slideway is flat and serves as a rolling area only for horizontally-arranged cylindrical rollers. Projecting from the top of the carriage are two special support members, as indicated at *M*, on which the cradle *N* rests. Three-point mounting of the type already described is provided for this cradle, which serves to support the standard to be checked. The latter is placed, inside the cradle, on special knife edges, as will be explained later.

Returning to the supports *M*, it may be noted that each is provided with means for vertical and horizontal adjustment, and such adjustments are made by the operator during the initial setting-up stages, movements being obtained by means of the two small handwheels seen associated with each support. The left-hand support, as viewed in Fig. 4, is of special design, and it is not rigidly secured within the carriage *L* but is flexibly mounted by means of a 4-arm parallel-motion system. Associated with this parallel-motion support there are two differential screw units, housed in the carriage *L*, one arranged vertically and the other horizontally. These screws can be turned by means of two 1-in. diameter shafts which extend along the upper surface of the bed, one passing through, and the other passing beneath, the carriage. The upper of the two shafts, which passes through the carriage, is indicated at *P* in Fig. 4, and its associated support at the left-hand end of the bed may be clearly seen.

At the right-hand ends, these shafts pass through the wall of the cylinder which encloses the comparator and through the insulating wall of the control room, and enter the back of the control desk seen at the centre in the heading illustration. Here, they are connected to shafts which can be turned by hand from the operator's station, and universal joints are provided at various points in these transmissions, as required. With this arrangement, the two differential screw units mentioned above can be actuated remotely, from the control room, to deflect the left-hand cradle support in the vertical and horizontal planes.

Since the object of these arrangements is to restore parallelism to the mirror at the right-hand end of the standard after the carriage has been traversed, and thus compensate for any errors of straightness or flatness in the guideways on which the carriage moves, it will be obvious that the amounts of movement required are extremely small. It is for this reason that differential screws are employed, and a further reduction is obtained by applying the movements at the end of the cradle remote from the mirror. At the mirror end, of course, the movements are purely angular, comprising tilting in two directions, mutually at right-angles. The means by which the operator determines when parallelism has been restored will be explained later.

DRIVE TO THE CARRIAGE

It will be obvious that means must be provided for moving the carriage fairly rapidly over large distances—up to 1 metre when standards of that length are being checked—also for applying extremely slow and small movements when it is required to centre a graduation beneath the optical axis of a microscope. Primarily, movement is applied to the carriage by means of a fine-pitch screw and nut, the former being indicated at *R* in Fig. 4, and this arrangement is used, under power, to bring the carriage to within say 0·10 mm. of the required position. Second-stage movement is then applied by hand, by means of a knob on the control desk which turns the same screw by way of a very high reduction gear.

The third and final stage of movement is applied by means of a magneto-striction device, which it is stated allows the carriage to be displaced by amounts as small as 0·001 micron. It may be recalled that magneto-striction is the term used to describe the phenomenon whereby the dimensions of a magnetic material change when it is magnetized. This change is most marked in nickel, and the arrangement employed here provides, in principle, for a bar of nickel to be electro-magnetized, the amount of current employed being under the control of the operator. This bar is coupled directly to the end of the carriage traversing screw, and when current is applied and the bar is reduced in overall length, the complete screw and carriage are moved by a corresponding amount.

In Fig. 5 is shown a close-up view of the right-hand end of the bed, with the traverse screw support and reduction box indicated at S. The nickel magneto-striction bar is housed within the cylindrical cover seen at *T*. Under full current, the nickel bar is stated to be reduced in length by about 5 to 6 microns, and losses due to friction and other factors in the mechanism result in a maximum movement of 4 to 5 microns of the carriage. The reduction of friction is obviously of primary importance when applying movements as small as those mentioned above, and it is interesting to note that the end bearings for the traversing

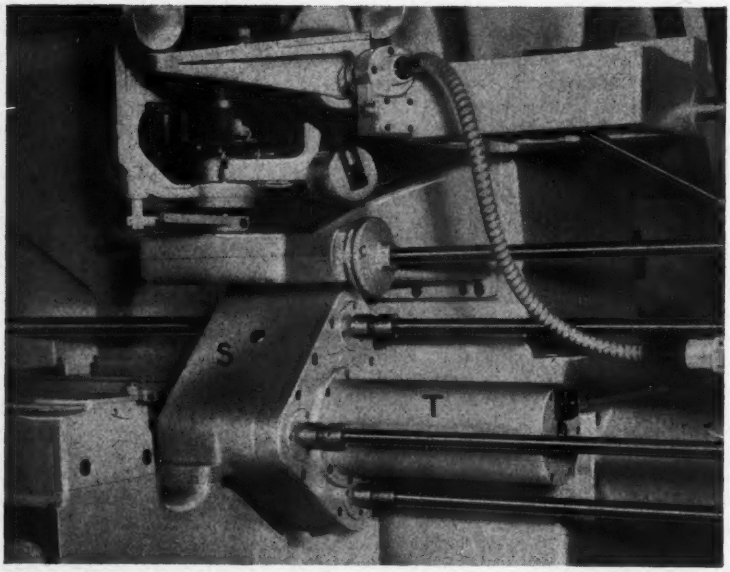


Fig. 5. In this close-up view can be seen the casing *T* which houses the magneto-striction bar whereby extremely small longitudinal movements are applied to the carriage

screw are contained in quills which are mounted, in turn, in linear ball bearings.

Moreover, since the complete screw requires to be moved axially it was not possible to provide bearing supports along its length, because the friction inherent in such units would be unacceptable. As a result, special arrangements had to be made to accommodate the sag of the screw, which is approximately 5 ft. long, and as mentioned above, is supported at the ends only. Tensioning of the screw axially was not possible—because it must be displaced as a complete unit—and it was decided to allow the screw to sag and to employ a special design for the nut whereby the small vertical movement is accommodated.

The arrangement is shown diagrammatically in Fig. 6, where it will be seen that there is a cast-iron plate *U* which projects from the under-side of the carriage. This plate has a forked portion which is slightly wider than the screw, and through which the latter passes without contact. The nut *V* is in two halves, secured together by screws, and completely embraces the screw, but has a thread in the upper portion only. A special tongue *W*, projecting from the under-side of the nut, engages with a track machined in the throat of the bed, and serves to prevent the nut from rotating.

At the right-hand end of the nut there is a cylindrical peg, which abuts another peg projecting from the left-hand side of the plate *U*. A tension spring, connected to the nut and the plate *U*, maintains the pegs in close contact. With this arrangement, the nut *V* can rise and fall in accordance with the sag of the screw. Such movement results in the end faces of the two pegs sliding over each other, and no vertical deflecting forces are exerted on the carriage. The coil spring is of sufficient strength to tow the carriage, when the nut is moved to the left, without the end faces of the pegs coming out of contact.

Mention may be made at this point of a telemetering system whereby the longitudinal position of the carriage is relayed to a special instrument on the control desk. Similar facilities are provided to enable the operator to ascertain the longitudinal positions of the two photo-electric microscopes. The left-hand end bearing of the traverse screw incorporates a selsyn, which is driven directly from

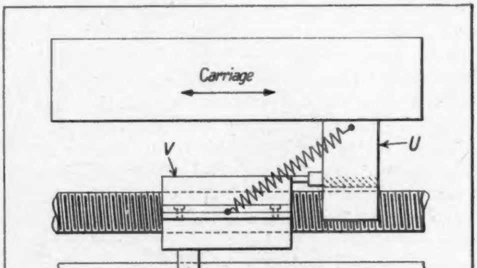


Fig. 6. Diagrammatic layout showing the design of the nut whereby the carriage is traversed

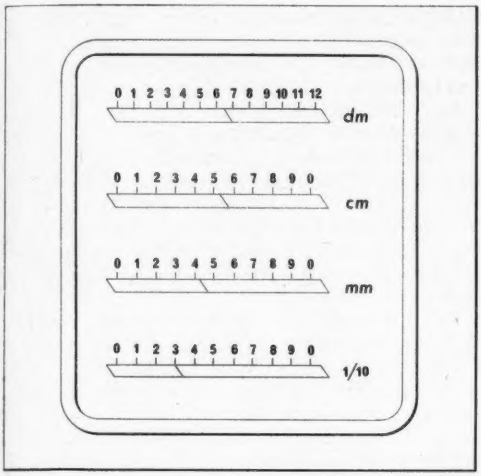


Fig. 7. This special instrument is incorporated in one of the control desks and shows the longitudinal positions of the carriage or the microscopes

the screw, and similar selsyns are provided for relaying the movements of the microscopes. In Fig. 2, the latter selsyns are indicated at *Z*. Signals from these selsyns are transmitted to an instrument on the control desk, and a switch permits the operator to select "carriage position" or "microscope position" at will. The selsyns are of special design and require an extremely low current, and any heating which might affect the temperature of the air surrounding the comparator is therefore kept to a minimum.

The face of the instrument incorporated in the control desk is shown in Fig. 7, and it can also be seen at the centre of the right-hand desk in the heading illustration. Of the two instruments there visible, the one under discussion is the lower. Referring again to Fig. 7, it will be seen that the instrument is provided with four narrow rectangular slits, which read in descending order of magnitude in decimetres, centimetres, millimetres, and tenths of millimetres. Behind each slit there is a cylinder, and gearing is provided whereby these cylinders are rotated by the receiver selsyns. Each cylinder is provided with an engraved helical line on the periphery, and these lines are visible through the slits. The setting shown on the instrument in Fig. 7, for example, indicates a reading of 654·3 mm. An instrument of a similar type is used in connection with another function of the photo-electric microscopes, and more detailed reference to it will be made later in the article.

Before leaving the carriage and associated equipment, mention may be made of the means whereby the standard to be checked is mounted inside the cradle *N*, Fig. 4. It is supported at the Bessel points in the manner shown diagrammatically in Fig. 8. The left-hand support is a conventional knife-edge, but the right-hand support comprises an accurately ground steel cylinder, the ends of which are ground away to form two inverted knife edges, as shown in the perspective view. These knife edges rest in V-grooves in a block secured to the cradle, and the standard is carried on the upper cylindrical portion of the support. With this arrangement, the standard to be checked is supported by transverse line contact, in the required manner, but is not subjected to any longitudinal restraint, as would be imposed if two conventional knife edges were provided.

It will be appreciated that a mirror must be mounted at the end of the standard, to provide for measurement or comparison by interferometry, and such a mirror is shown in position on a standard at *A* in Fig. 4. The weight of the mirror assembly must be counterbalanced, since it would otherwise apply a bending force to the end of the standard with which it is associated.

To this end, a pivoted arm and counterweight *B*, Fig. 4, is provided, which has a fulcrum point on a small platform projecting from the cradle *N*. Very fine adjustment is provided for the position of the counterweight, and with this arrangement it is possible completely to compensate for the weight of the mirror assembly.

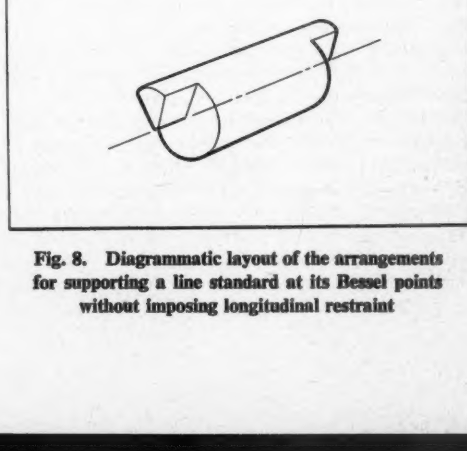


Fig. 8. Diagrammatic layout of the arrangements for supporting a line standard at its Bessel points without imposing longitudinal restraint

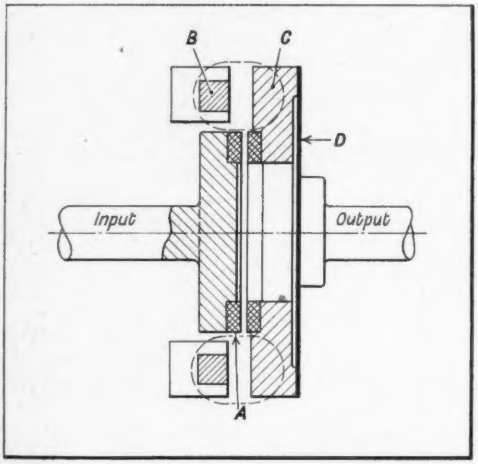


Fig. 9. This line drawing shows the principle of design of the special magnetic clutches which are incorporated in the drive to the carriage and the microscopes

SPECIAL MAGNETIC CLUTCHES

The motors from which drive is transmitted for traversing the carriage, also the photo-electric microscopes, are housed in the control desk at which the operator is seated in the heading illustration. There are two motors, mounted with their axes parallel one above the other, and one is of higher horse-power than the other. This larger motor serves for the high-speed movements of the carriage, or microscopes, over fairly long distances, whereas the smaller motor is employed for the second stage movements, when approaching the positions at which manual control is engaged. The larger motor drives the outer member of a jamming-roller free-wheel, and the smaller drives the inner member, by way of a high-reduction gear train. There is a common output shaft which is connected by means of a flat belt to a further gearbox, from which three output shafts project, and extend through the back of the cabinet.

Special disc-shaped self-aligning couplings connect these shafts to intermediate shafts, carried in bearings in the insulating wall of the control room, and it may be noted that the intermediate shafts are of special design and material to ensure that heat is not transmitted from one side of the wall to the other. Additional shafts, for controlling various functions of the comparator, by hand or power, also project from the back of the desk and are connected to intermediate shafts in the insulating wall. Some of these shafts can be seen in Fig. 2, where the insulating wall is represented by the two steel plates *E*. The second gearbox, mentioned above, incorporates electro-magnetic clutches, whereby drive to the carriage or to the microscopes can be selected at will, by means of rotary switches. Since this gearbox is of the constant mesh type, it is essential that there shall be no residual friction in the clutches which are disengaged, otherwise drive might inadvertently be transmitted to the carriage, for example, when the microscopes are being traversed.

To this end, the electro-magnetic clutches employed are of a special design, and the principle is shown diagrammatically in Fig. 9. Here it will be seen that the input shaft has a flanged end with a facing *A* of frictional material, and that the flange portion is surrounded by a stationary coil *B*. The output shaft is also provided with a flange, as indicated at *C*, which in this instance is a separate member and is supported from the shaft by means of a thin, spring-steel, disc-shaped diaphragm *D*. The flange *C* has a frictional facing similar to that provided for the input shaft.

When the coil B is energized, the magnetic field embraces the area enclosed by the dotted line, and the flange *C* is pulled to the left. The diaphragm *D* is thus deflected (into a saucer-shape) and the two frictional facings are brought into contact. In this condition, drive is transmitted from the input to the output shaft. Immediately the coil *B* is de-energized, however, the diaphragm *D* re-asserts itself, to take up the position shown in the figure. An air gap between the two frictional facings is thus assured, and there is no possibility of drive being inadvertently transmitted.

THE PHOTO-ELECTRIC MICROSCOPE

One of the greatest contributions towards the outstanding accuracy achieved with the apparatus has been the development and application by the company of the high-power photo-electric microscopes employed. The equipment incorporates two of these units, and the design is shown diagrammatically in Fig. 10. Here, the microscope is assumed to be in use for accurately locating a line standard, in the longitudinal direction, the standard being indicated at *G* and the graduations being shown greatly exaggerated, as V-shaped notches.

A low-power lamp, with a filament of suitable size, directs light by way of the condenser *H* through a slit in the plate *J*. The width of this slit (about 35μ) is predetermined, and is arranged to be set to a size that is equal to the width of the

graduation on the scale multiplied by the power of the objective lens *K*. The length of the slit can be adjusted to suit the width of the two parallel fiducial lines on the standard, which extend longitudinally and embrace the graduations. Light from the slit is projected by a 4-mirror system on to one half of the objective lens *K*, and with this arrangement an image of the slit is directed on to the surface of the scale to be checked.

Light from the surface of the scale is projected upwards, through the other half of the objective lens, and passes through the prism *N*. This prism serves to deflect the light slightly, to direct it on to the semi-reflective mirror *P*, whence it is passed to the photo-electric cell *R*. Some of the light passes through the mirror *P* and is reflected by the plain mirror *S* to the reticule *T*, which is located in front of an eyepiece.

The line being observed on the standard is of a V-shape, in cross-section, and it will be appreciated that if the apex of the vee is brought into coincidence with the optical axis of the microscope, no light will be reflected from the surface of the scale on to the photo-electric cell *R*, because the image projected from the slit in the plate *J* is equal in width to the mouth of the vee. In principle, therefore, it is necessary only to move the scale longitudinally beneath the microscope until zero output is obtained from the cell.

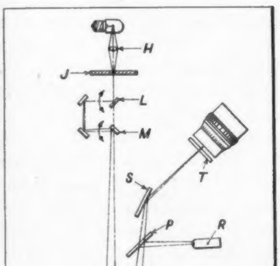


Fig. 10. Diagram showing the principle of operation of the photo-electric microscopes incorporated in the comparator

The arrangements for moving the carriage which supports the scale have already been described, and it will be recalled that initial power traverse is succeeded by manual operation, and that ultimately extremely small movements of the utmost sensitivity are applied by means of the magneto - striction device. This procedure is continued until the reading from the photo-electric cell shows that a zero position has been reached, and it is stated that in this manner a line can be located within a few millionths of a millimetre.

MEASUREMENT AND COMPARISON WITHOUT INTERFEROMETRY

Reference was made earlier to measurement and comparison of line standards without the use of interferometry. These operations are carried out solely with the aid of the microscopes, by an ingenious arrangement which allows one to be used as a fiducial indicator and the other as a linear measuring instrument. The system employed is best described in connection with the comparison of two line standards, one of which is a master. In setting up, the two standards are placed on the carriage end-to-end, and by means of the facilities afforded for vertical and transverse adjustment, they are accurately aligned with each other in all planes.

Next, the two photo-electric microscopes are positioned with the optical axis of one and the effective optical axis of the other accurately aligned with the first line on its associated line standard. Longitudinal movement is then applied to the carriage to bring the next line on the master standard beneath its microscope, and this movement is continued until a zero signal is obtained from the photo-electric cell. This microscope is employed, in effect, as a fiducial indicator. It will be appreciated, however, that unless the distance between the axes of the first and second lines on the other scale is identical with that on the master, a zero signal will not be obtained from the second microscope, since its optical axis will be off-set from the observed line. This procedure, therefore, informs the operator that an inaccuracy between the two scales is present, but does not reveal the extent of such inaccuracy.

To explain the means whereby this inaccuracy is measured, reference must be made again to Fig. 10. It will be noted that the mirrors *L* and *M* are pivoted, as indicated by the arrows, and the mirror *L* can be oscillated at high-speed by electrical means. Oscillation of this mirror will result in the image of the slit in the plate *J* being "swept" across the surface of the scale, so that the line which is being observed is scanned.

Oscillations of three different amplitudes can be applied to the mirror *L*, according to the degree of accuracy required, and the corresponding fields of sweep are 10, 200, and 1,000 μm. For these values, the magnifications obtained are 650,000, 32,000 and 6,500 ×, respectively.

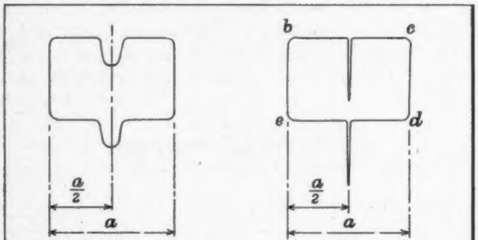


Fig. 11. Actual and modified wave-forms from the photo-electric cell in a microscope

As the image of the slit sweeps across the scale, the light which is reflected through the right-hand portion of the objective *K*, and thence to the photo-electric cell, will vary. In effect, the intensity of the reflected light will be at its maximum while the image is on the plain surface of the scale, but immediately the image overlaps the line the intensity will fall off sharply. Maximum density, as it may be termed, occurs when the image is coincidental with the line, since in that condition no light is reflected on to the photo-electric cell. It will be appreciated, therefore, that the output from the cell *R* will be in the form of a curve, with a sharp fall and an equally sharp rise, and that if the optical axis of the microscope is off-set from the line being observed, this curve will not be at the centre of the scan.

It will be appreciated, however, that by pivoting the mirror *M*, the sweep of the image can be displaced on the scale until the curve of the output from the cell *R* is symmetrical. Pivoting the mirror *M* in effect brings the optical axis of the microscope coincidental with the line on the standard, and is therefore equivalent to moving the microscope, or the carriage, longitudinally. The mirror *M* is pivoted electrically, by direct current, and this facility is used initially, for setting purposes. It may be mentioned that arrangements are made for moving the mirror *M* in either microscope independently.

Assuming the line on the scale to be centred accurately with the optical axis of the microscope, the output from the photo-electric cell will approximate to the shape seen at *W* in Fig. 11. This signal is modified, electrically, to that seen at *X* in Fig. 11, and is used to trigger two current flows which are equal in magnitude but opposite in direction. Diagrams corresponding to the original and modified outputs from the photo-electric cell when the optical axis of the microscope is off-set from the scale line are shown at *Y* and *Z* in the figure.

In the view *W*, Fig. 11, the distance *a* represents the span of the sweep of the image on the scale, and not only is the sweep distance maintained within very close limits of accuracy, but also the frequency of oscillation, and consequently the time required to sweep the distance *a*. With the condition represented by the diagram at *X* in Fig. 11, therefore, the pulse which occurs when the current is flowing in one direction (say when the image is moving from *b* to *c*) is precisely midway—in terms of time—as is the pulse which occurs when the image is moving in the opposite direction from *d* to *e*. With the condition represented by the diagram *Z*, Fig. 11, however, the pulse occurs after ¾ of the time required to scan the scale line has elapsed (when travelling from *f* to *g*) and after ¼ of the time required has elapsed when travelling from *h* to *k*.

Signals from the equipment that is employed to generate the equal and opposite current flows (which is known as a bi-stable flip-flop circuit) are used to produce a square-wave form output, and with the condition shown at *X* a balanced form will be produced. On the other hand, the condition seen at *Z* will produce an unbalanced wave form. Signals from the flip-flop circuit are fed to a phase comparator, and in this unit are compared with other signals which are transmitted from what may be termed a "slave" photo-electric microscope, in one of the control desks. The operating principle of this device is basically similar to that of the microscope on the comparator, in that it has a light source, a slit, and a photo-electric cell. It also incorporates oscillating and tilting mirrors, and the arrangement is such that the output received from the cell is similar in nature to that received from the microscope on the comparator.

The outputs from both instruments, after being suitably modified, are fed to the phase comparator, as already mentioned, and differences between the two sets of signals are employed to actuate a servo mechanism. This unit pivots an optical flat in the slave instrument, by means of a worm and segment arrangement, and this pivoting movement continues until the output from the slave microscope cancels

that from the photo-electric microscope on the comparator. A reading is then taken from a special direct-indicating instrument, which will be described in some detail later.

It was realized, however, that the operator would have no indication that the tilting flat in the slave instrument had taken up the required position other than by observing that the reading instrument mentioned above was stationary. It was considered remotely possibly that by some unforeseen circumstance—such as an increase in friction in part of the tilting mechanism—the flat might come to rest even though the two sets of electrical signals had not yet reached agreement. In such circumstances, the reading instrument would be stationary, but a false value would be obtained. To obviate this possibility, a dial-indicator instrument is provided in the control desk, a portion of the dial being visible through a small window.

The periphery of the dial is provided with graduations, and a zero mark, and there is an index line on the window glass. As long as there is a difference between the two sets of electrical signals being compared, this dial shows a reading other than zero. In normal circumstances, the dial gives a zero indication coincident with the reading instrument becoming stationary, thus providing corroboration for the operator that the sets of signals are in agreement. If the reading instrument is stationary, however, and the dial-type unit is not reading zero, the operator is warned that a fault has developed and that the two sets of signals are not in agreement.

It will be recalled that a worm and segment are employed for tilting the optical flat in the slave instrument, and the worm serves not only to turn the segment but also to drive three cylinders, which are arranged parallel to each other and are geared to each other successively in the ratio of 10 to 1. Each cylinder is engraved with one or more helical lines and is located behind a narrow rectangular slit, through which parts of the helices are visible. There are three such slits, and the upper and lower edges of each slit are calibrated in linear terms, for example, units, tenths and hundredths of a micron.

Mention has already been made of the oscillating mirror of the photo-electric microscope (*L*, Fig. 10) and of the fact that it can be oscillated at three different amplitudes, to cover fields of 10 μ, 200 μ and 1,000 μ. Three different magnifications are thus obtained (650,000, 32,000, and 6,500 $\times$ respectively), but by an ingenious arrangement the reading instrument described above serves for all three magnifications and incorporates a lighting system which obviates all possibility of ambiguity. A line drawing showing the face of the instrument is given in Fig. 12, as it appears to the operator when the photo-electric microscope is set to cover a field of 10 μ (650,000 $\times$ magnification). The three slits are indicated, and attention is drawn to the three small rectangular windows at the right-hand ends of the slits. In Fig. 12, the values 1, $\frac{1}{10}$ and $\frac{1}{100}$ μ are seen in these windows, and appear automatically when the microscope is set, by a switch, to cover the 10-μ field.

It will be seen that a portion of the helix is visible through the top rectangular slit, as are portions of the other helices in the centre and lower slits. In Fig. 12, graduations are seen along the top edges of the slits only, although in fact both edges of the top slit are graduated. It is arranged that the graduations along the top edge of the top slit are red, and the helix on the top cylinder is black, as are the graduations on the centre and bottom slits.

On each of the remaining cylinders there are two helices, one of which makes two complete turns along the length of the cylinder. The other helix has two starts and each start makes one complete turn. These helices are painted red and green, respectively, on each cylinder. The graduations along the bottom edge of the top slit are green.

When the microscope is set for a field of sweep of 10 μ, and the required values automatically appear in the small windows at the right (as seen in Fig. 12), the face of the instrument is flooded

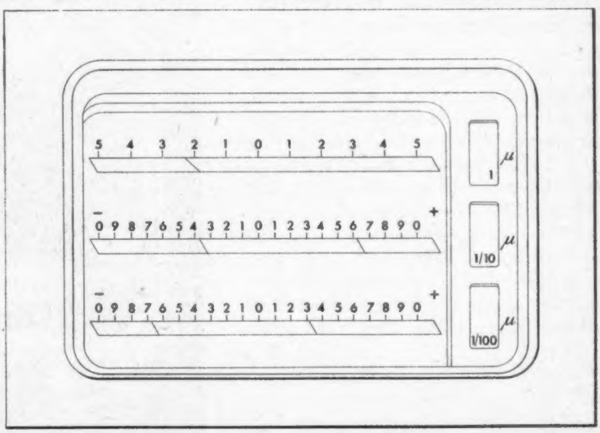


Fig. 12. The face of the instrument whereby measurements can be taken of the amount by which a scale mark is off-set from the axis of a photo-electric microscope

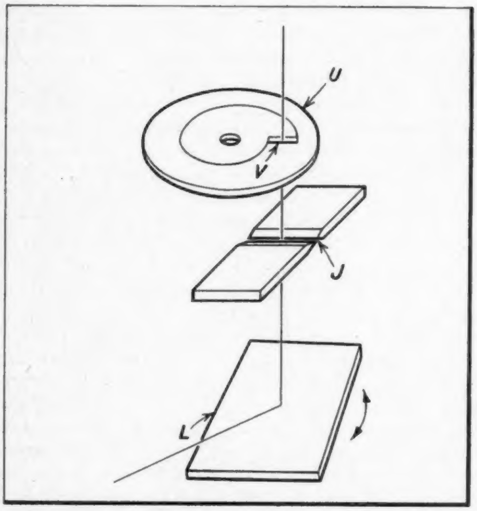


Fig. 13. Schematic arrangement of the closed-circuit television whereby the surface of the scale is checked for dust

with green light. As a result, the red graduations and helices appear black, whereas the green graduations and helices disappear. Green light is also employed to flood the dial face when a field of sweep of 1,000 μ is selected, the values then shown in the right-hand windows being 100, 10 and 1μ.

It will be noted that the graduations are arranged in ascending order starting from a central zero mark, and the sense of the reading is taken from the position of the portion of helix visible in the top slit. In Fig. 12, the top slit shows a reading to the left of the zero mark (that is, a minus quantity) and the readings on the centre and bottom slits are interpreted likewise. For the setting shown in Fig. 12, the reading is $-2{\cdot}368$ μ and this represents the displacement of the true optical axis of the photo-electric microscope from the line on the scale.

When the microscope is set to sweep a field of 200 μ, the dial face is flooded with red light, with the result that the green graduations and helices appear black and the red markings disappear. With this setting, the reading is obtained from the bottom edge of the top slit. Other readings are provided by the centre and lower slits, in each of which portions of the single 2-start helix are now visible, the positions of which are noted in relation to the top edge graduations.

It will be appreciated that the required colour for illuminating the dial face is obtained automatically by the switch which sets the field of sweep, and the possibility of the operator making an error of selection is thus eliminated. The instrument is extremely easy to read, and the lighting system described above virtually eliminates any possibility of mistakes, even though provision is made on the one instrument for the three different magnitudes of magnification.

The instrument is incorporated in the control desk at the right in the heading illustration, and is the upper of the two seen at the centre. Diagrammatic representations of the two photo-electric microscopes are also provided on the panel of this desk, and can be seen at the extreme left and right of the black centre section. When the microscopes are being moved, arrows are illuminated to show in which direction traverse is taking place, and similar diagrams and arrows are employed to represent the scales being checked and the movements of the carriage. When one microscope is being used as a

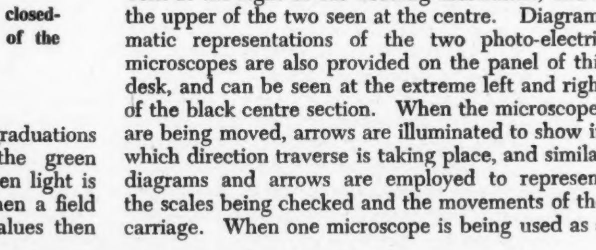


Fig. 14. Close-up view of the Michelson interferometer and the platform on which the Fabry-Perot etalon is mounted

fiducial indicator, a white spot is illuminated on the appropriate diagram, to indicate that the axis of this instrument is the origin of measurements.

Mention has already been made of a simple form of closed-circuit television which is incorporated to allow the operator to check the surface of the scale being measured for the presence of dust. It will be appreciated that if there is any dust close to the line being swept by the photo-electric microscope, extraneous reflections will be caused, which will be picked up by the photo-electric cell and will result in a confused signal. The well-defined output curve which is required will thus be unobtainable, and the accuracy of reading will be greatly diminished. The control desk at the right in the heading illustration incorporates a small oscilloscope, to which a signal is fed from a special mechanism in the microscope.

This mechanism is shown in diagrammatic form in Fig. 13. The slit plate *J*, Fig. 10, is similarly lettered in Fig. 13, as is the oscillating mirror *L*. Interposed between the slit plate and the light source there is a metallized glass disc *U* with a transparent Archimedean spiral that makes one complete turn, and a slot *V*. Arrangements are made to lock this disc so that the slot *V* is coincident with the slit in the plate *J* when the microscope is in use. To bring the device into operation, the disc *U* is driven by a small electric motor, and the spiral then causes a small square of light to sweep across the surface of the scale. If no dust is present on the scale, the trace on the oscilloscope shows only an image of the graduation line. The presence of foreign matter in the field of sweep, however, causes other, smaller, traces to appear on the screen, which are readily visible to the operator.

THE INTERFEROMETRY EQUIPMENT

The Michelson interferometer which is incorporated in the equipment can be used for the measurement and comparison of lengths up to approximately 1 metre. Alternatively, measurements of that order can also be made by using the Michelson instrument in conjunction with a Fabry-Perot etalon, and a description of this procedure will be given later. A close-up view of the Michelson interferometer is shown in Fig. 14, and the small platform indicated at *W* serves to support the Fabry-Perot etalon when it is in use.

It may be mentioned here that the front vertical face of the platform *W* also serves to support a third interferometer, of the Michelson type, which is used when it is required to determine the refractive index of the air within the cylinder in relation to that in a vacuum. The light source,

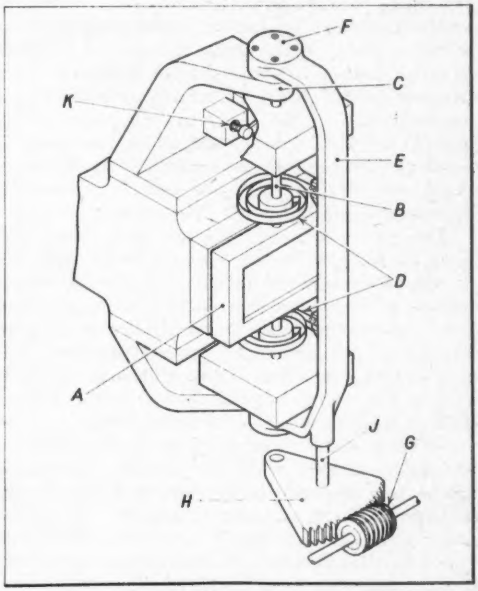


Fig. 15. This line drawing shows the means adopted for turning the compensating plate of the Michelson interferometer through very small angles

condenser system, and monochromator for the interferometric equipment are located separate from, and well outside, the enclosing cylinder, and the beam is directed through a window incorporated in the wall of the latter. Three disc-shaped plain mirrors, seen approximately facing the camera in Fig. 14, are carried on a bracket which is pivoted on the frame of the Michelson interferometer, and form part of the optical system for bringing the Fabry-Perot etalon into use, also the interferometer for checking refractive index.

The bracket can be swung about a horizontal pivot by means of a cable within the flexible casing *X*, and can be turned through approximately 180 deg. in either the clockwise or anti-clockwise direction. It is counterbalanced by means of the weight *Y*, and is controlled remotely, by hand, from the operator's console seen at the centre in the heading illustration.

A necessary component of the Michelson instrument is a compensating plate, which can be tilted. By this means, the length of the light path can be changed, to enable fractions of interference fringes to be measured to a very high degree of accuracy. The angle through which the com-

pensating plate requires to be tilted is extremely small, since for a difference of one wave-length of an infra-red ray in the usable part of the spectrum, the inclination is 20 sec. of arc. It follows that a displacement of 0·001 of a fringe corresponds to an inclination of the compensating plate of 0·02 sec. of arc. Obviously, special means must be employed for applying so small an angular movement, also for measuring it, since conventional mechanisms would be quite inadequate.

The system adopted is shown diagrammatically in Fig. 15, where the frame which holds the compensating plate is indicated at *A*. This frame is provided with two torsion bars, as at *B*, which are accurately coaxial, and are held in supports *C*. Associated with each torsion bar there is a clock-type spring *D*, and in each instance the inner end of the spring is attached to the torsion bar, and the outer end to a frame member *E*. This frame is pivoted on bearings, as at *F*, which are arranged coaxially with the torsion bars, and it can be moved angularly through 60 deg. by means of the worm and segment *G* and *H*. It will be noted that the segment *H* is pivoted at a point which is coincidental with the centre line of the torsion bars, and incorporates a peg *J* which projects upwards, and engages with the frame *E*.

When angular movement is imparted to the frame *E*, the springs *D* are wound or unwound, according to the direction of rotation, and as a result the torsion bars are loaded or unloaded to turn the compensating plate. It will be appreciated that great care must be taken in selecting and matching the torque characteristics of the bars and the springs to achieve the required results, but with this arrangement it is stated that an angular movement of 3 min. of arc of the segment *H* results in a movement of 0·02 sec. of arc of the compensating plate, which is equivalent to a reduction of 9,000 to 1. The measurement of an angular movement of 3 min. of arc of the segment *H* presents no particular problem, and is facilitated by the provision of a graduated drum on the spindle of the worm *G*. In the heading illustration, the operator is seen holding the knob whereby the worm *G* is turned.

It is understood that the company has devised two systems whereby interference fringes can be observed, converted into electrical signals, and suitably modulated, to allow readings to be taken.

A photo-electric technique is used to detect the interference fringes, and is incorporated for the following reasons. When the interferometric technique is employed over long distances—and in this context, 1 metre may be considered to be a long distance—the contrast of the fringes diminishes, and they become increasingly difficult to distinguish with the naked eye. They can, however, be detected photo-electrically.

Moreover, when considering long distances, it may sometimes be advantageous to use "long" wave-lengths—possibly from the infra-red portion of the spectrum—which are not visible to the naked eye and can only be detected photo-electrically.

With one of these systems, the compensating plate is oscillated at a known frequency by means of the coil and magnet indicated at *K* in Fig. 15, and the output takes the form of a trace on a cathode ray tube. This system is still in course of development, and no further details can be given at present.

With the other method, use is made of a photo-multiplier, and the arrangement can best be described with reference to the diagrammatic layout shown in Fig. 16. In this figure,

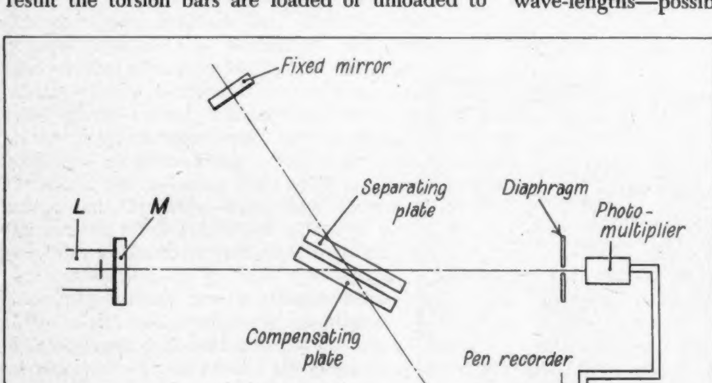


Fig. 16. Diagrammatic layout of the Michelson interferometer and of the photo-multiplier and pen-recorder whereby the fringes are detected

the standard being checked is indicated at L, and the mirror which is attached to its right-hand end at M. It will be appreciated that this mirror is the " moving " mirror of the interferometry equipment, and is equivalent to that shown at A in Fig. 4. Referring again to Fig. 16, it will be noted that the fixed mirror is shown, as are the compensating plate and the separating plate. The compensating plate is arranged for tilting by means of the mechanism described in connection with Fig. 15, and at the right there is a diaphragm, incorporating a very small-diameter hole, and a photo-multiplier.

The fringes fall on to the diaphragm shown in Fig. 16, and it will be appreciated that as the alternate black and coloured concentric circles appear and pass, alternate peaks of maximum light and maximum " density " will be detected by the photo-multiplier through the pin-hole in the diaphragm. The output from the photo-multiplier is fed to a moving-paper pen-recorder, as seen at the bottom right on Fig. 16, and is suitably modified to produce a trace of the type shown. The distance between the peaks on the trace represents one wave length of the particular light source that is being used.

Application of the equipment will be described in connection with the measurement of the distance between the two end graduations on a metre line scale, and in Fig. 16 one graduation can be seen adjacent to the mirror on the end of the scale. It should be explained that the equipment is employed only to measure the fraction of a fringe, since the whole number of wave-lengths between the lines on a scale of this quality is already known. It may be useful to recall at this point that the procedure involves centring one graduation on the scale beneath the optical axis of a photo-electric microscope, taking an interferometric reading, displacing the scale to centre the other graduation beneath the microscope, and finally taking a second interferometric reading. The difference between the two readings expresses the distance between the graduations in terms of wave-lengths, and can be compared with the stated distance between the graduations to reveal the error of the scale.

In practice, three separate and successive measurements are taken employing three different wave-lengths, the latter being selected by means of the monochromator. The procedure for taking a measurement is as follows. A known wave-length is selected on the monochromator, and the compensating plate on the Michelson interferometer is turned until a peak reading is observed on the pen-recorder. The calibrated dial associated with the manual control for turning the compensating plate is then set to zero. The compensating plate is now turned a second time, until the next peak is observed on the recorder, and when this condition is reached a note is made of the reading on the calibrated dial. Let it be assumed that this reading is 39, which, it will be understood, represents one wave-length.

The dial is then re-set to zero and the carriage is traversed to bring one line on the standard beneath the optical axis of the microscope. Next, the compensating plate is turned once more, until a peak is observed, and a second reading is obtained from the calibrated dial. Let it be assumed that this reading is 14. Now the expression $39/\lambda_1 = 14/x_1$ can be considered, where 39 and 14 are the readings from the dial, λ_1 is the wave-length selected, and x_1 is the fraction of a fringe which it is required to calculate. It follows that $x_1 = 14\lambda_1/39$.

Next, the dial is set to zero once more and the carriage is traversed to bring the other line on the scale beneath the optical axis of the microscope. The compensating plate is then turned until a peak is observed on the pen-recorder, and the setting of the dial is noted. Let it be assumed that this setting is 24. The expression $39/\lambda_1 = 24/x_2$ can now be considered, where x_2 is the fraction of fringe obtained from the second interferometric reading. By adding or subtracting x_1 and x_2 the total fraction of a fringe by which the distance travelled by the carriage exceeded a whole number of wave-lengths is obtained, and this fraction may be designated f_1.

This value is then used in the expression

$$(\lambda_1)\ W_1 + f_1 = L \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

where W_1 = the whole number of wave-lengths of the value selected; f_1 = the sum (or difference) of the two fractions x_1 and x_2; and L = the total length moved expressed in terms of wave-lengths, all in reference to λ_1 the wave-length selected.

The procedure described above is then repeated with another wave-length (λ_2) to obtain fractions x_3 and x_4, and ultimately a final fraction f_2, which is related to the second wave-length to produce the expression

$$(\lambda_2)\ W_2 + f_2 = L \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

After the third stage, the expression

$$(\lambda_3)\ W_3 + f_3 = L \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

is obtained. By considering the expressions (1), (2) and (3) and employing the method of coincident fractions, a unique value for L can be found.

It may be recalled that after the carriage has been traversed to bring the second graduation beneath the microscope, it is necessary to adjust the attitude of the standard being checked in order to restore the mirror at its right-hand end

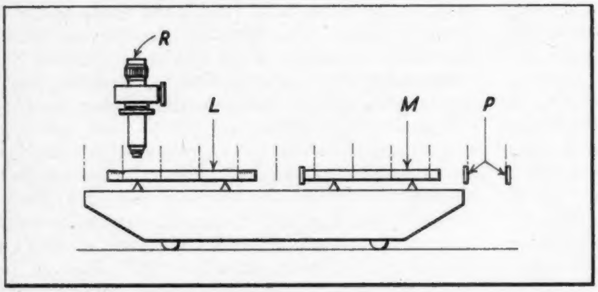


Fig. 17. The arrangement for comparing an end standard with a line standard is here shown diagrammatically

to parallelism. These adjustments are made by deflecting the left-hand support for the cradle holding the standard, as has already been described. The interferometry technique is extremely sensitive to errors of parallelism, and the latter are manifested very clearly in the shape of the trace made by the pen recorder. Any slight deviation from parallelism has the effect of reducing the amplitude of the trace, and may sometimes result in a straight line only being produced. Adjustments are made to the cradle support until a maximum amplitude is obtained on the trace, which indicates that parellelism has been restored.

USING THE FABRY-PEROT ETALON

The Fabry-Perot equipment is brought into use when it is required to compare a metre end standard with a metre line standard, and the arrangement for this operation is shown diagrammatically in Fig. 17. Here it will be seen that a line standard *L* is mounted end-for-end with an end standard *M*, and that the latter has a mirror secured to its left-hand end. The right-hand end of the standard *M* is suitably prepared, and serves as a second mirror. The Fabry-Perot etalon is indicated at *P*, and comprises basically two half-silvered optical flats which are spaced apart by a known distance. Usually, the flats are secured to the ends of a U-section bar, or a hollow cylinder, and the important feature is that the distance between them is known precisely.

As already mentioned, the etalon is mounted on the platform *W*, Fig. 14, which is provided with adjustable seatings whereby the etalon can be set accurately, vertically and horizontally. These seatings are moved by differential screws which are actuated, through shafts and universal joints, by knobs provided on the control desk. The etalon is illuminated by white light, which gives rise to a series of virtual images of its mirrors along the measuring axis. These images are indicated by the short vertical chain-dotted lines in Fig. 17, and are spaced at intervals equal to that between the mirrors on the etalon. The procedure provides for bringing one end of the end standard *M* into optical coincidence with one of the virtual images of the etalon, and for taking a reading from the photo-electric microscope. Next, the operation is repeated for the other end of the standard *M*, and the length of the latter can then be expressed as a multiple of the length of the etalon, plus or minus the measured displacement of the line standard.

The photo-multiplier and pen-recorder are used for this system, and when one end of the standard *M* is moving between two virtual images the output on the moving chart is virtually a straight line. As it approaches one of the virtual images, however, a well-defined wave-form of progressively increasing amplitude is produced, as a result of using white light. The wave-form is of the type shown in Fig. 18. When the peak of intensity of light is reached, indicated by the point *X* in Fig. 18, the end of the standard is in coincidence with a virtual image, and the carriage is stopped. If the point *X* is over-run, the carriage can be moved back by the magneto-striction device until the required position is reached.

SPECIAL PREMISES

Finally, attention may be drawn to some features of the special premises which are required to house the comparator and its associated equipment. In Fig. 19 are shown views in plan, section, and elevation of the compartment containing the comparator, and of the adjacent remote control room.

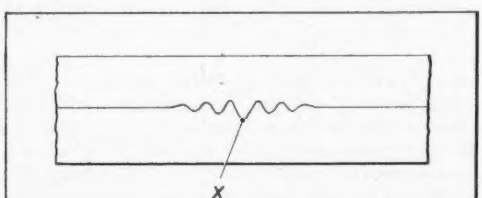


Fig. 18. Typical trace on the pen recorder obtained when using white light and the Fabry-Perot etalon

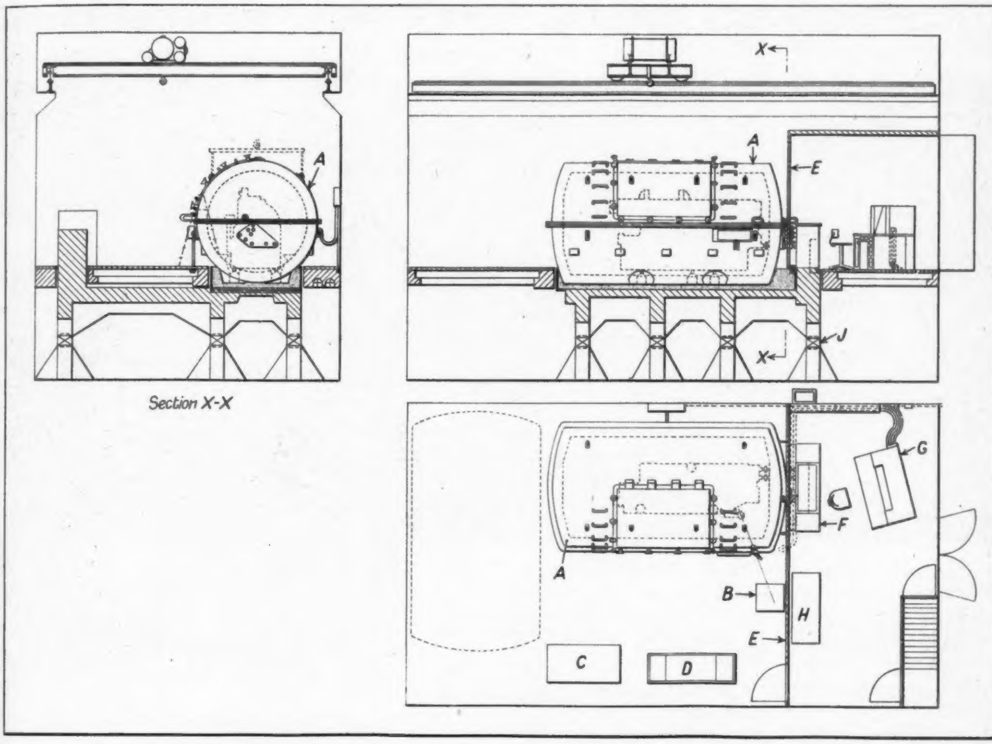


Fig. 19. Views in plan, section and elevation of the special premises built to house the SIP longitudinal comparator. The apparatus is housed within the steel cylinder *A*, and is shown in dotted outline in all views

The steel cylinder is indicated at *A*, and the longitudinal split at the centre line can be seen. In the elevation, the hoist for removing the upper portion of the cylinder is shown, and in the plan view the position occupied by this member when removed is indicated in dotted outline. In all views, the outline of the comparator within the cylinder is shown dotted, and in the plan view, the krypton 86 light source is indicated at *B*. In the sectional view it will be seen that the cylinder is set in a bed of concrete, and that there are piers immediately below, which are thermally insulated from corresponding piers built up from the basement. The outlines at *C* and *D* represent equipment connected with the control of the environmental conditions within the room, and *E* is the insulating wall which separates the main compartment from the control room.

In the control room, the two desks are located at *F* and *G*, the latter being that seen at the right in the heading illustration. The area at *H* in the control room is reserved for the storage of various types of ancillary equipment associated with the installation.

The importance of the elimination of vibration has already been stressed, and this aspect presented the major problems when the equipment was being installed at Sèvres. It will be noted from Fig. 19 that the comparator is mounted on a base which has a number of piers projecting from its underside. These piers are coincident with a similar number which extended upwards from the basement, and between the ends of each pair of piers there is a special vibration-absorbing unit, as indicated at *J*.

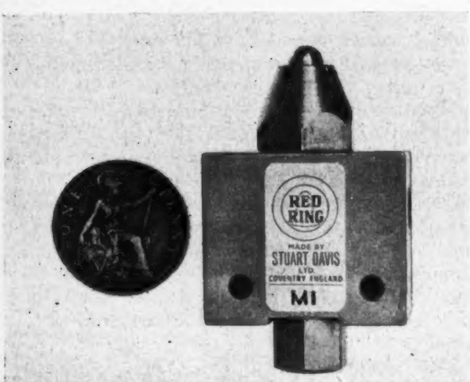
This unit consists of a battery of eight compression springs, at the centre of which there is a hydraulic dash-pot type damper. Since there is a total of 12 piers, there are 96 springs and 12 dashpots, and it is stated that, to date, this arrangement appears to offer the most satisfactory solution to the problem of eliminating the vibration (of extremely

small amplitude) which can exercise such an exaggerated effect on the behaviour of the interferometry equipment.

Finally, further mention may be made of the special temperature-measuring equipment which is incorporated on the premises. The equipment was built by H. Tinsley & Co., Ltd., Stanger Road, London, S.E.25, to a design put forward by the N.P.L., Teddington, and close co-operation was also maintained with the B.I.P.M., Sèvres. A number of resistance-type thermometers are connected to the line or end standards being checked, also to various positions on the comparator itself, and these thermometers are connected, in turn, to a Smith Bridge type 3 measuring instrument. Switches are provided whereby any resistance thermometer can be selected at will, and it is stated that temperatures can be measured to an accuracy of a few ten-thousandths of a deg. Celsius (C.).

Red Ring ⅛-in. B.S.P. Pneumatic Valves

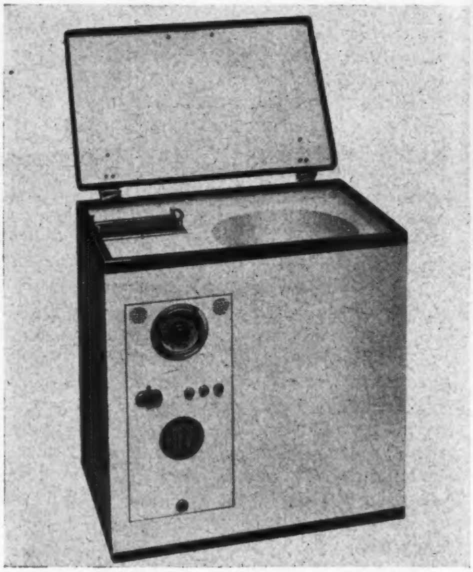
A recent addition to the range of Red Ring pneumatic valves made by Stuart Davis, Ltd., Stonebridge Highway, Willenhall, Coventry, is shown in the figure. Known as the M.1., this ⅛-in. B.S.P. cam-operated pilot valve is suitable for controlling a pilot pressure-operated valve or a small single-acting cylinder. A wide range of ⅛-in. B.S.P. valves is being made to meet a variety of requirements, and their compactness will be evident from the accompanying illustration.



The Red Ring type M.1, ⅛-in. B.S.P. cam-operated pneumatic pilot valve is here shown in comparison with a penny

A.E.W. Drying and Pre-heating Unit

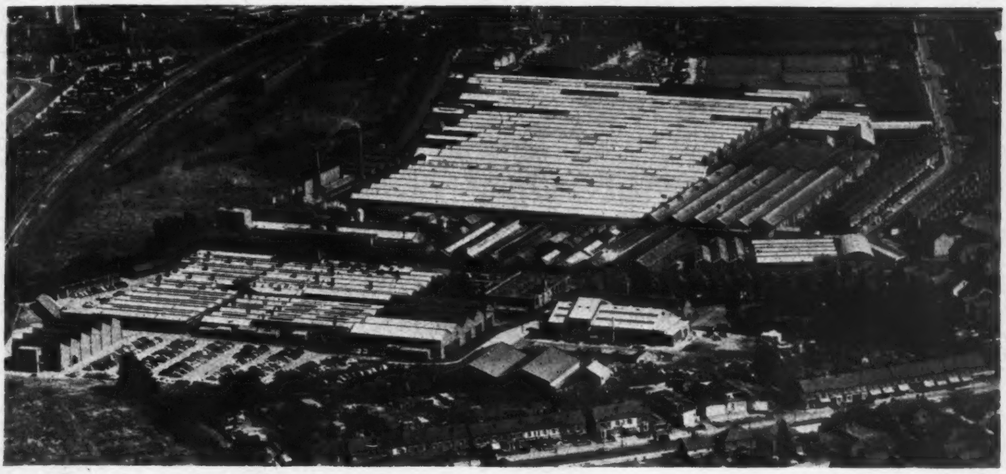
Recently introduced by A.E.W., Ltd., Imperial Works, High Street, Edgware, Middx., the hopper-



A.E.W. drying and pre-heating unit, for granulated plastics moulding materials

fed unit seen in the figure is intended for drying and pre-heating granulated plastics moulding materials before delivery to a moulding machine, and is the subject of a patent application. The unit, which has a capacity of 75 to 100 lb. per hour, and is suitable for mounting on top of a machine, measures 28 by 18½ by 25 in. high.

The hopper has a capacity of 1·5 cu. ft., and the unit is normally arranged to provide temperatures between 40 and 100 deg. C. Heat is supplied electrically, and for this operating range, the total power consumption is less than 1·5 kW. A control, which may be locked after adjustment, provides for setting the working temperature, and when the hopper is full, a value of 80 deg. C. is reached in one hour after starting from cold. A warning lamp is illuminated when the hopper should be re-filled. The entry of dust and dirt is prevented by a tightly-fitting lid, and to obviate the need for completely unloading the hopper at the end of a shift, a silica gel unit is incorporated, whereby the moulding material is protected from moisture.



Alfred Herbert, Ltd., Head Works, Coventry

By P. A. SIDDERS, Chief Associate Editor

ALTHOUGH NOT THE OLDEST machine tool firm in this country, Alfred Herbert, Ltd., Coventry, are certainly the largest in the U.K., if not in the world. The name of Herbert has become synonymous with capstan, combination turret and auto lathes, which account for the major proportion of the company's output, but the range of products also includes drilling, milling and boring machines of various types, also an extensive variety of cutting tools and ancillary equipment. Moreover, the company acts as agent for a large number of British and foreign makers of machine tools, production equipment and associated products.

"The machine tool alone, of all things created by man reproduces itself, under his guidance, in continually improving generations." In a number of articles to be published in MACHINERY, of which this is the first, attention will be drawn to some of the ways in which modern machine tools are being utilized by machine tool builders in this country to enable the dual requirements of quality and quantity to be met economically

The foundation of the company can be traced to the partnership of Alfred Herbert and William Hubbard, who had been school-fellows and apprentices together at the Leicester firm of Joseph Jessop & Son, crane builders and general engineers. The partners bought the small Coventry engineering company of Coles & Mathews, in 1889, and under the name of Herbert & Hubbard, built boilers and carried out general engineering jobbing and repair work. Later, they built simple machine tools for the bicycle trade, the first of which was a polishing lathe, followed by small drilling machines, hand lathes, and special machines, for example, for hub and rim drilling, spoke screwing and cone and cup grinding. The hand lathes were of simple design with headstock and tailstock and were fitted with compound slide rest.

When the partnership was dissolved in 1894, a small limited liability company was formed, with the name of Alfred Herbert, Ltd., which, after many years, became a public company. The founder (later Sir Alfred Herbert, K.B.E.) retained

(Continued on page 968)

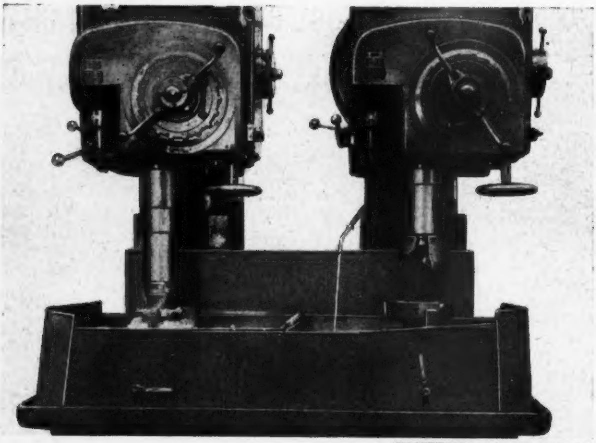


Fig. 1. It is the company's practice to drill previously cut-off blanks before they are passed to lathes and similar machines. In the raw-material preparation section of the Head Works there is a large battery of Russell Hydrofeed cold saws, adjacent to which are installed two Archdale twin-column drilling machines, as here shown. With blanks held in 3-jaw chucks mounted on the machine tables, holes up to 3 in. diameter are produced with a Herbert straight-flute drill, and holes up to $6\frac{1}{2}$ in. diameter with a special trepanning cutter, as seen at the right

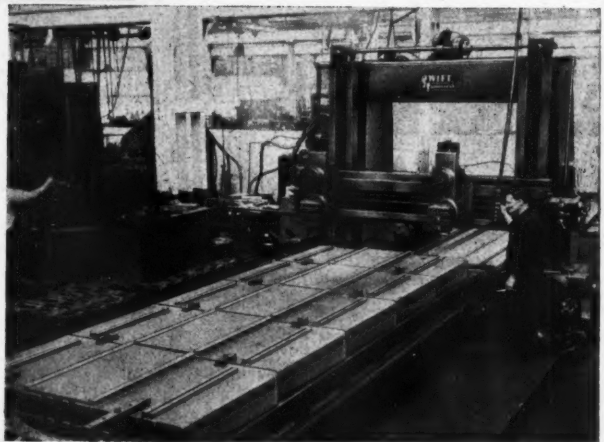


Fig. 2. This Swift-Summerskill planer will admit 6 ft. between the columns and has been installed primarily for planing saddles for Herbert type 28 and 49 milling machines, six at a time. The machine is here seen set-up for planing the dovetail guideways, T-slots and other surfaces on the front faces of five lower columns for Herbert 6-spindle drilling machines using Ardoloy tools. These operations were previously carried out on one column at a time on a plano-miller. The machine has a 36-ft. bed, an 18-ft. table, two cross-rail toolboxes and two side boxes

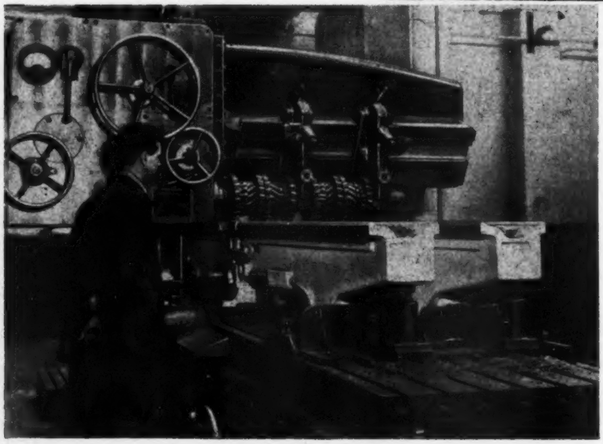


Fig. 3. Milling the assymetrical guideways on two beds for No. 7 Preoptive combination turret lathes simultaneously. The vertical and horizontal surfaces are first machined by a gang of seven high-speed steel cutters, with diameters from 6 to 10 in. At the next stage, the vees are rough milled with two pairs of cutters, and then the complete form is gang milled, as here shown, at a spindle speed of 24 r.p.m. and a feed rate of $6\frac{1}{2}$ in. per min. The Kendall & Gent machine was specially built for Alfred Herbert, Ltd., and can be used for profile milling with cam bars mounted at the side of the table

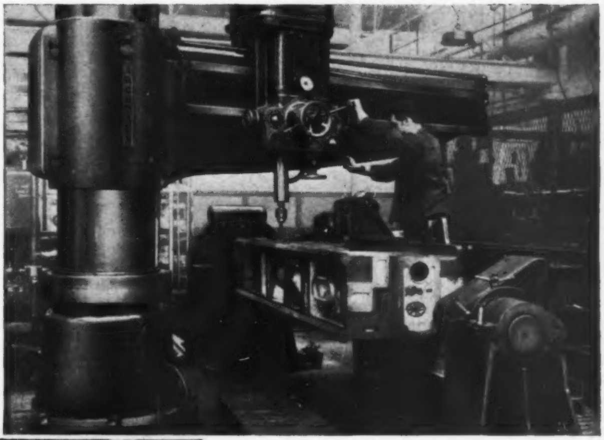


Fig. 4. A total of 60 holes, from $\frac{3}{8}$-in. Whitworth tapped to $1\frac{3}{8}$-in. diameter reamed, is machined in the top, bottom and two side faces of the bed for a No. 5A auto lathe, at this set-up on an Archdale heavy-duty 9-ft. radial drilling machine. The motor-driven trunnion fixture was designed and built by Alfred Herbert, Ltd., and has a work-support that can be plunger-located at 90-deg. intervals. This equipment is used for other lathe beds, including those for No. 9C, No. 8 Preoptive and No. 3 Preoptive machines, also for suds trays and the main bases for milling machines

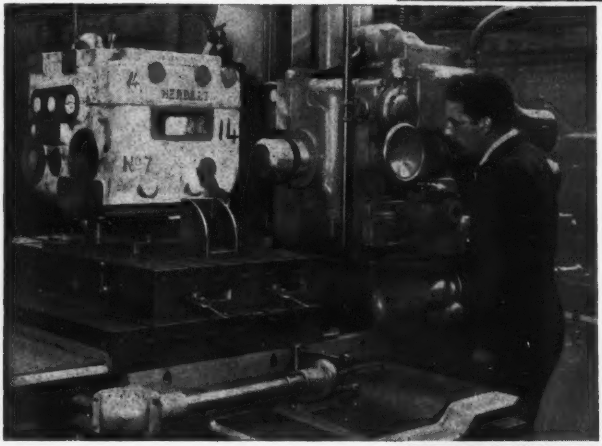


Fig. 5. At the Head Works of Alfred Herbert, Ltd., extensive use is made of DeVlieg Jigmils for machining the headstocks and similar main castings for the company's capstan, turret and auto lathes. A type 3B-48 machine is here seen set up for precision machining the headstock for a No. 7 Preoptive combination turret lathe. All four sides of the component are machined at one set up, and the operations include drilling and boring 32 external and internal holes from $\frac{7}{8}$ to $8\frac{3}{4}$ in. diameter, counterboring and front and back facing. Microbore tooling is widely employed, and the production time is approximately 11 hours. The Jigmil is one of a battery in the main machine shop, which includes Herbert/DeVlieg 2B-36, and American-built 4B-60 machines

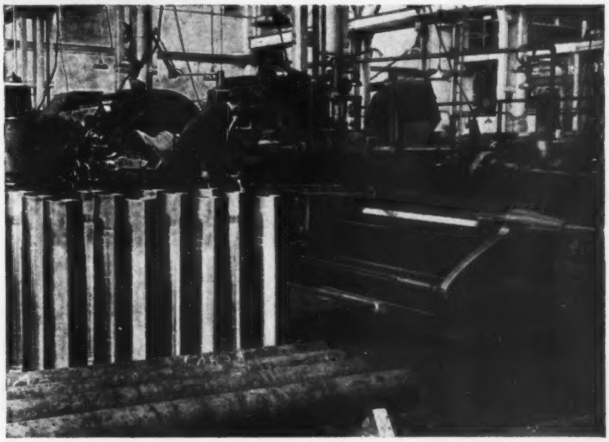


Fig. 6. A Herbert No. 14/36 combination turret lathe in the heavy turret lathe section of the main machine shop at the Coventry works is here being employed for machining a pulley for an Atritor pulverising unit. The pulley is 14 in. diameter and has eight V-grooves. In the foreground are main headstock spindles for No. 9C combination turret lathes, which are machined (including through boring) in 220 min., also billets for Atritor main shafts. At the left are control drums for No. 3A auto lathes, and in the background may be seen a No. 9C/30 combination turret lathe

Fig. 7. The 40 sets of slip gauges used in the Alfred Herbert organization are checked at intervals, depending upon usage, in the A.I.D.-approved standards room at the Head Works. Checking is performed against a reference set that is calibrated at regular intervals by the N.P.L., and this set has recently been re-calibrated on the basis of the internationally-agreed standard inch. The Sigma Superset electronic comparator shown provides direct readings to 0·000002 in. For transport to the standards room, a special steel box, developed by the company, is used, wherein the plastics box for the set of gauges is supported by leaf springs

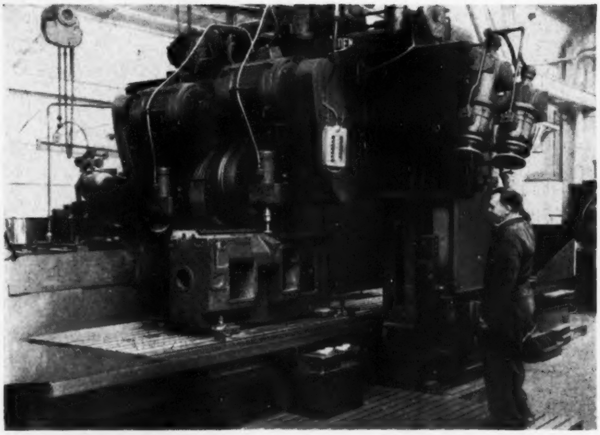


Fig. 8. Finishing the turret slideways on the bed for an Auto Junior chucking automatic, on a special Lumsden grinder built to Alfred Herbert specification. The flat surfaces are first ground with the 24- by 3-in. wheel on the main front head, and then the V-surfaces, with a profiled wheel on the main rear head. Finally, the lower surfaces of the ways are ground with auxiliary, vertical spindle heads, of Herbert design, mounted on the main heads. The machine table measures 20 ft. by 5 ft. 8 in., and there are nine motors for the wheel and traverse drives, the motors for the main heads being of 15 h.p.

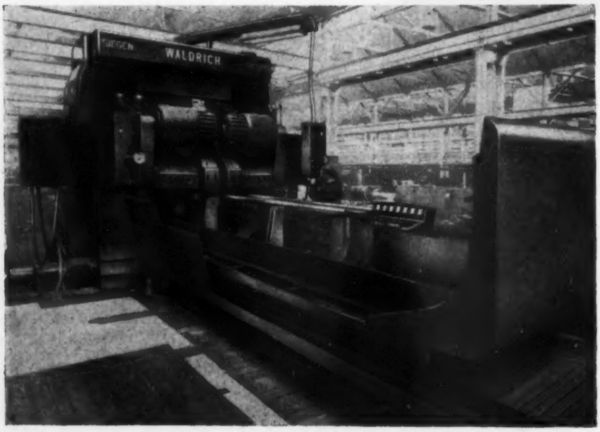


Fig. 9. This recently installed Waldrich Siegen slideway grinder is seen set up for finishing the slideways on a 10-ft. long bed for a No. 9C combination turret lathe. All six faces of both bed-ways are ground simultaneously by diamond formed wheels, of 24 in. diameter, in 4 to 5 hours. The two wheel-heads are driven by 20-h.p. motors, and all movements of the machine are controlled from the pendant or console. Driven by rack and pinion, the machine table has white-metal lined bearing surfaces that move on steel bed-ways. The bed-ways are ground before flame hardening, and the bed is then subjected to drilling and associated operations before the ways are finally finish ground

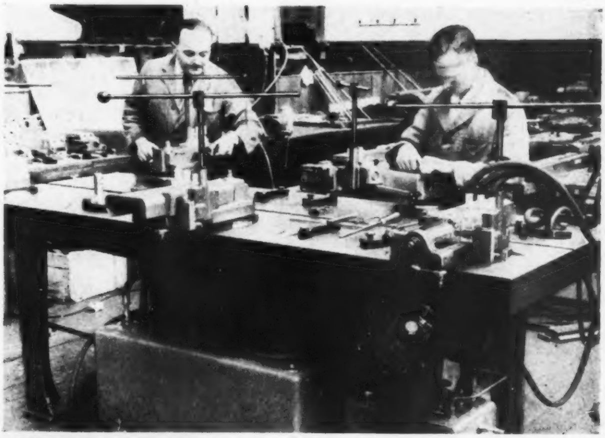


Fig. 10. To eliminate testing and setting on the machine assembly lines, hydraulic copying attachments for Herbert No. 4 Senior and No. 5 Senior capstan lathes, and No. 7B combination turret lathes, are assembled and tested in this section. Five stations are arranged around a marking-out table which ensures the necessary rigidity, and pressure oil supplied from a unit below can be connected to any station. Each attachment is secured to the table by arcuate clamp plates, and rests on a plastics disc to prevent damage to the base member. A pressure of 500 lb. per sq. in. is employed for testing

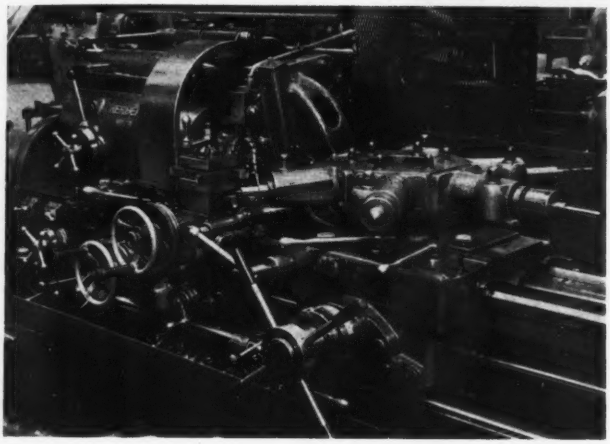


Fig. 11. Alfred Herbert, Ltd., are making increasing use of their own capstan and turret lathes to replace centre lathes for toolroom work, since the former are more versatile and more productive. This No. 7B combination turret lathe is set up for machining a single component. A blank, $7\frac{1}{2}$ in. diameter by $3\frac{3}{8}$ in. long, is turned to produce a $7\frac{1}{2}$ in. diameter by $\frac{3}{8}$ in. wide flange, with a 3 in. diameter spigot, and a 2 in. diameter hole is bored through the work. The machining time was 30 per cent less than that originally required on a centre lathe. When the machine was used for turning high-speed steel blanks for taper reamers, in batches of 12, the saving in time was 25 per cent

Fig. 12. One of a number of special Herbert machines for operations on seatings in bars and holders for Microbore tools. It has a standard lathe bed, feed box, and saddle, and a special headstock provides 16 spindle speeds from 14 to 1,335 r.p.m. Work is mounted in a V-block on a support at the left, which is vertically adjustable on a slide, and the latter has horizontal motion on a swivel plate, micrometer screws being provided. Holes can be machined accurately at the required angles to the bar or holder, and quick traverse of the headstock is used for broaching keyways

Fig. 13. This machine, incorporating a standard drilling base, has been built by Alfred Herbert, Ltd., for grinding internal splines and accurate keyways. The abrasive wheel, mounted at the lower end of the ram, is belt driven, and the ram slide is traversed by air cylinder on the column guideways. A Centec air-operated indexing table is used to support the work, and can be turned in increments as small as 5 deg. The smallest splined bore that can be handled on the machine has a minimum diameter of $1\frac{1}{16}$ in. Side faces of splines in all headstock sliding gears are ground, and the gear shown is for a No. 9C combination turret lathe

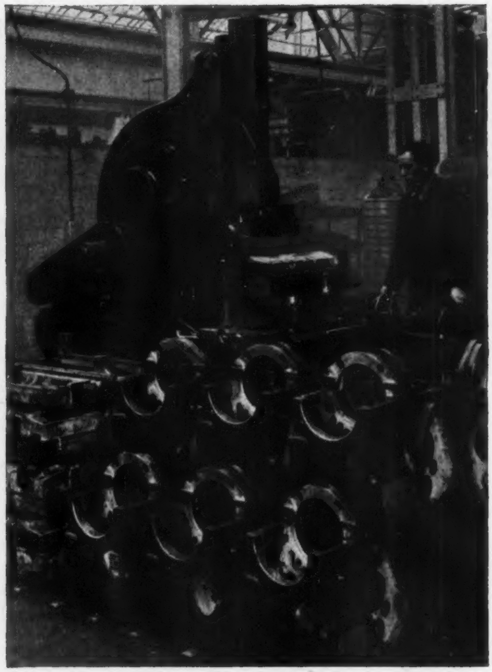


Fig. 14. Machining the turret slide for a No. 3A Auto lathe at the Alfred Herbert Head Works. The Butler 12-in. precision toolroom slotter employed is fitted with an indexing table with a dividing head, and the capacity of the machine can be increased by the provision of an adaptor, when required. At the set-up shown, a rectangular hole is cut in the work for the passage of the trigger that actuates the turret locking bolt. The Butler machine is run at a speed of 75 cutting cycles per min. and the length of stroke is 3 in. This slotter is used for machining a variety of components, some of which are seen stacked in the foreground

an active interest in this company as chairman and managing director until his death in 1957, in his 91st year. The Herbert organization now includes four factories and five subsidiary companies, with a total floor area of 1,426,700 sq. ft. There are some 7,336 employees, and more than 3,350 machine tools are in operation. The main company has eight branches in Great Britain, associated companies in Australia, India, France, and Italy, and agents in 57 other countries.

Between the first and second world wars, the company outgrew the original factory at The Butts, Coventry, and activities were concentrated at Edgwick, the site of the present Head Works, where foundries and pattern shops had then been established, and some machine tools had been produced. Just before the second world war, a new factory was built at Exhall, Coventry, and was specially equipped for the manufacture of dies, taps, and threading equipment. During that war, a Government factory at Lutterworth was leased to the company for building certain types of machine

tools. This factory was subsequently purchased from the Government and expanded, and will form the subject of a later article in this series. A large part of the former works of the Rover company at Red Lane, Coventry, was purchased during the war when it was impossible to erect new buildings. These premises provide for machine tool rebuilding, and the demonstration, storage, and sale of factored machines and small tools. There is also a department for the supply of machines and equipment for the plastics and die casting industries.

It may be of interest here to mention some of the developments that have taken place in connection with Herbert machine tools. The first No. 4 capstan lathe was built in 1895, and more than 24,000 machines of this capacity have now been built. As originally designed, this machine has a chasing saddle for cutting right- and left-hand threads, and the tool and nut were simultaneously withdrawn by the action of a single lever. A fully automatic screw machine, with magazine feeding, was introduced in 1899, and a patented design of single-pulley headstock in 1900. Self-opening dieheads have been associated with the name of Herbert for many years, and the Coventry diehead was developed in 1901. Later, the company introduced the covered V-type bed-ways, and in 1932 developed the Flamard treatment for lathe beds and slides. Since the bearing surfaces of these units are ground after heat-treatment the company contributed significantly to the development of machines for this purpose. Among the most important of the company's innovations was the introduction of the Preoptive headstock, in 1934. With this headstock, an operator could preselect a spindle speed, and then engage that speed by movement of a single lever, with the result that non-cutting times were reduced and speeds could be changed while cutting was in progress. Subsequently, the Preoptive mechanism was improved, and is now power operated, under push-button control. Developments have also been made in connection with the feed drive systems of milling machines, and in 1947 the company introduced steplessly-variable arrangements to replace the heavy feed gearboxes on their machines. These arrangements were based on the use of d.c. electric motors, operating under thyratron control.

The Head Works at Edgwick, with which this article is concerned, is seen in the heading illustration, and occupies an area of approximately 500 acres. Among the facilities provided are several office buildings, laboratories (including the recently-opened new premises for the Applied Research Department*), demonstration bays, a pattern shop and associated stores for timber and finished patterns, and two foundries. The No. 1 foundry has cupola capacity of 6 tons of iron per hour, and a maximum output of castings of approximately 70 tons per week. Normally, the maximum weight of casting produced is 3 tons, but castings weighing up to 6 tons can be made if required. The No. 2 foundry has an output of about 55 tons of castings per week, the maximum weight of casting being 2 cwt. Castings are produced on a mechanized track system, moulding boxes being transferred from the moulding machines, past a cupola for pouring, and thence by a serpentine route, that provides for cooling, to a knocking-out grid. A new specialized plant for the production of castings is now in production, these castings being required for Herbert Atritor dryer-pulverisor units, which the company builds in a range of seven sizes with outputs of 850 to 15,000 lb. per hour.

In the heading illustration, the main machine shop is seen extending to the rear from the centre of the illustration, and has an area of 9¼ acres under one roof. It is arranged in bays, of which there are 30, each bay being approximately 30 ft. wide by 420 ft. long. The shop is intersected by two main gangways which extend for the full length—about 900 ft.—and there are 66 overhead traversing cranes with capacities ranging from 1 to 15 tons. Machine tools are arranged in groups according to type, as far as possible, and work flows from bay No. 1, nearest to the camera in the illustration, towards the erection, testing and despatch sections at the other end of the shop. Machine tools of an extremely wide variety of types and designs are installed, and particular reference may be made to the extensive use of the company's own capstan, turret and auto lathes. In this connection it may be noted that capstan lathes are being increasingly employed in place of centre lathes in the toolroom. Another feature of the machine shop is the extensive use of slideway grinders, including some very large machines by Lumsden and Waldrich Siegen, and the application of DeVlieg Jigmils, built either by Alfred Herbert under licence or the American company, for operations on major machine tool components. Slave tables are provided for planing machines, and one table can be loaded while components on another table are being machined, thus substantially reducing non-cutting time.

In the main machine shop there is a training centre where new apprentices are given a thorough basic training in most aspects of machine tool engineering. It may be mentioned that the total number of boys employed in the factory is between 400 and 500.

Separate from the main machine shop are a self-contained factory for the production of turret

* See MACHINERY, 98/1433—21/6/61.

lathe tools, Coventry chucks, and sub-assemblies as well as Herbert drilling machines; another factory for Coventry dieheads, Herbert Multigrip clutches and coolant pumps; and a shop for the production of Ardoloy cutters and tools, with facilities for brazing, grinding and lapping the tool tips, which are supplied by A.E.I. There are also an A.I.D. approved laboratory and a standards room, the latter with a comprehensive range of modern equipment. Some typical machines, set-ups and items of equipment at the Head Works are seen in the illustrations on pp. 964 to 968.

Wickman Lo-Ten Blades for Face Milling

ALTHOUGH CARBIDE-TIPPED INSERTED-BLADE CUTTERS of double-negative form have been used for many years for face milling operations on high-tensile steel workpieces, such cutters are generally not suitable for machining low-tensile steels and components which have slender cross-sections or are prone to vibration, due to the high cutting pressures which are applied. To reduce this pressure, the shape of the blade should be such that smooth entry into the work is obtained, followed by a shearing action during cutting.

Wickman, Ltd., Banner Lane, Coventry, have recently introduced Lo-Ten cutter blades, which are particularly intended for face milling low-tensile steels, but may be advantageously employed for machining certain high-tensile steels. The design of the blades is indicated in the line drawing Fig. 1, and it should be noted that the various angles are such that zero true rake is obtained. Available in right- and left-hand forms, the blades can be mounted in the bodies normally used for Wickman Hi-Ten face milling cutters. In addition, Lo-Ten blades can be supplied for use with the company's Rapid Re-Set face milling cutters, which were described in MACHINERY, 97/289—3/8/60.

COMPARISON OF THE COMPONENTS OF THE CUTTING FORCES APPLIED DURING MACHINING TESTS WITH THREE TYPES OF MILLING CUTTER BLADES USING TWO FEED RATES

Blade Type	Feed Rate (in. per rev.)	Components of Cutting Force (lb.)		
		Tangential	Feed	Radial
Hi-Ten	0·0053	300	180	158
	0·011	520	253	246
Special	0·0053	280	205	88
	0·011	488	326	104
Lo-Ten	0·0053	280	121	31
	0·011	520	231	37

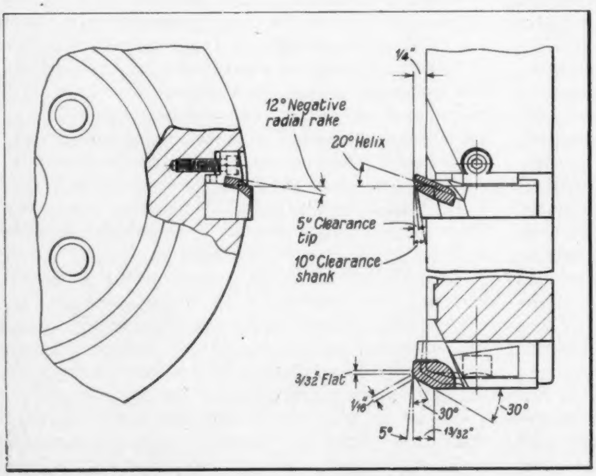


Fig. 1. End and side elevations, and a plan view, of the Wimet Lo-Ten cutter blade, mounted in a cutter body. The blade has zero true rake, and is intended for face milling low tensile steels, and parts liable to vibrate under high cutting pressures

To provide a comparison of the performance of Lo-Ten and Hi-Ten blades, reference may be made to a series of tests carried out by the company, using blades of both types, also blades of another form, designated "special", which had a 25-deg. helix angle, 20 deg. negative rake, 4 deg. negative true rake, and a 30-deg. bevel angle. Each blade had a $\frac{3}{32}$-in. flat and a $\frac{1}{16}$-in. chamfer at 45 deg., as viewed in plan, and ⅛-in. deep cuts were taken at two different feed rates at a speed of 400 ft. per min. Dynamometer readings of the tangential, feed and radial components of the cutting forces are given in the accompanying table. In particular, attention is drawn to the values recorded for the radial force components, and it will be observed that these components have very small values with the Lo-Ten blades, so

that the risk of the work vibrating is reduced. A further indication of the effectiveness of Lo-Ten cutters is afforded by the results of another test, in which stub axle forgings made from a steel of 75 tons per sq. in. tensile strength were milled on a duplex machine of fairly light construction, on which each cutter spindle was driven by a motor of only 7½ h.p. Both spindles were run simultaneously, but a cutter with Hi-Ten blades was mounted on one spindle, and a cutter with Lo-Ten blades on the other. Totals of 28 and 128 components, respectively, were machined before re-grinding became necessary, and the longer life of the Lo-Ten blades was attributed to the reduction in vibration due to the easier cutting action.

At the Norwich works of Laurence Scott & Electromotors, Ltd., cutters with Lo-Ten blades are used for milling a number of different workpieces, amongst which is the U-section gearcase assembly shown in Fig. 2, which is weld-fabricated from ⅛-in. thick steel plate. On this workpiece, the edges round the semi-circular aperture are machined to a flatness tolerance of 0·002 in., to serve as joint faces, and it will readily be appreciated that there is considerable risk of vibration during the milling operation. A 10-in. diameter cutter, with 10 Lo-Ten blades, is employed, and a cut of approximately $\frac{1}{16}$ in. deep is taken at a speed of 500 ft. per min., with a feed of 12 in. per min. The finish produced is completely satisfactory and no difficulties are experienced due to vibration. In another set-up, on a column-type horizontal machine equipped with a 20-h.p. driving motor, the edges of projections on large cast steel generator magnets are milled. Although the workpiece is generally of substantial proportions, the projections are unsupported and are thus liable to vibrate. Cuts ranging from $\frac{3}{16}$ to ⅜ in. deep are taken by an 8-in. diameter Lo-Ten cutter, at a speed of 220 ft. per min., and a feed rate of 6 in. per min. is employed. The use of Lo-Ten blades permits machining without the generation of high cutting pressures normally associated with the milling of steel, and vibration is therefore reduced to an insignificant level.

Fig. 2. In the works of Laurence Scott & Electro-motors, Ltd., a cutter equipped with 10 Lo-Ten blades is used for machining the edges around the aperture in this fabricated half-casing, and a flatness tolerance of 0·002 in. is maintained

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MAGNETIC SEPARATOR FOR WELDING FLUX.—When surplus flux applied for submerged arc welding operations is collected for re-use, small particles of mill scale are frequently picked up at the same time.

These particles may cause porosity, and because they are magnetic they may be held in the field around the electrode with resultant clogging of the flux feed. To remove such particles before the flux is used again, a magnetic separator has been introduced by Armco, Ltd., 76 Grosvenor Street, London, W.1.

This separator takes the form of a cylindrical hopper of 10 in. diameter by 3 in. deep. There are slots in the bottom of the hopper through which the flux passes, and below the slots solid cylindrical magnets are so mounted that they can rotate as the flux passes over them.

Underneath the magnets there is a hinged cover which is also slotted and serves to restrict the flow of flux to a rate that permits effective particle removal.

It is stated that with the equipment any mild steel submerged arc flux and certain types of hard-surfacing fluxes can be processed.

An Incentive Wages Payment Scheme

Some Details of a Scheme which has been Employed by Ransomes, Sims & Jefferies, Ltd., Ipswich, in Recent Years

By A. W. ASTROP, Associate Editor

A SERIES OF ARTICLES was published recently in MACHINERY* on certain aspects of the practice and equipment employed at Ransomes, Sims & Jefferies, Ltd., Ipswich, for the quantity production of Sprite and Conquest lawn-mowers. It may be recalled that the facilities provide for a fully-assembled, adjusted, and run-in Sprite machine to be delivered to the packaging section every 4 min., and a Conquest machine every 1¼ min. The company produces a very wide range of equipment, including ploughs and agricultural implements; combine harvesters; cereal-processing equipment; crop driers; small tractors; petrol and diesel engines; machine tools; electric motors and electrical control gear; a range of hand, motor, electric and gang mowers, in addition to the Sprite and Conquest machines mentioned above; and industrial and fork-lift trucks and tugs, also a wide range of forgings, castings, pressings and sheet steel fabricated parts.

The total number of people employed on a clock-in basis is of the order of 3,250, distributed among the company's factories in Ipswich and at Nacton—about three miles away. Until 1955, a conventional piece-work payments system was in operation, but in the previous year the management decided that this procedure was out-of-date and had a number of inherent disadvantages for the type of work in which the company was engaged. Under the piece-work system, an individual worker has little or no interest in the finished product, and, generally speaking, is concerned only with the number of parts he can produce per shift. It follows, also, that he is usually opposed to interruption during a run, since his bonus will almost invariably be adversely affected.

Moreover, the natural tendency for the section foreman to allocate short runs of difficult workpieces to operators who are more skilful, or have more interest and initiative, results in the less-skilled workers benefiting unfairly, since they receive simpler workpieces, on which the runs are longer. In consequence, it was decided to investigate the possibility of introducing a simple, more equitable arrangement, which, at the same time, would ensure that the earnings of employees were not adversely affected.

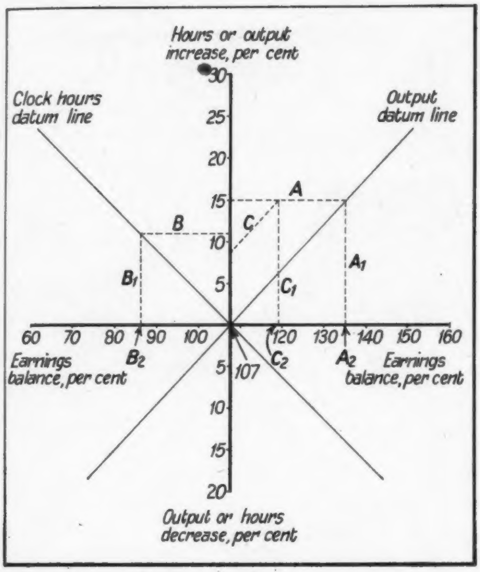
It may be noted that the scheme which was eventually devised was first instituted for direct production workers only, but proved to be so successful that—at the request of representatives of the various Trades Unions with members in the company—it was extended to cover indirect workers. The company also reports that since the scheme was introduced in 1955, enquiries for full details have come from most countries of the world.

THE BASIS OF THE SCHEME

The scheme is based on a direct relationship between the weekly net sales value of all finished products, spares, and customers' general orders, etc., and the weekly total of clock hours of attendance by direct production and ancillary workers. From these two factors, the weekly earnings balance (bonus) is calculated, and is paid to all employees covered by the scheme. The average of the weekly bonuses for each quarter is then paid for the following quarter. With this arrangement, employees receive a certain earnings balance percentage on their base rate, and the latter is in direct relationship to the corporate productive effort of the company as a complete unit. It follows, therefore, that if an increased weekly value of products can be obtained without an increase in clock hours, or the weekly value of products remains unchanged but is obtained with fewer clock hours, then the earnings balance for the employees will rise. If, on the other hand, the weekly value of products remains unchanged but the number of clock hours increases, or the weekly value of products decreases while the number of clock hours remains constant, then the weekly earning balance for the employees will diminish. There is, of course, a number of additional combinations of these factors, all of which ultimately result in an increased or diminished weekly earnings balance.

To start the scheme, an acceptable datum point for an earnings balance value had to be found. An analysis of the company's accounts for 1954 showed that the average earnings balance of each employee

* 98/60—11/1/61; 98/189—25/1/61; 98/303—8/2/61; and 98/362—15/2/61.



This graph is employed to facilitate calculating the weekly earnings balance paid to employees under the incentive wages payment scheme operated by Ransomes, Sims & Jefferies, Ltd., Ipswich

on the old piece rate system was 97 per cent of the basic rate. This figure was raised to 107 per cent, and was used as the base for the new system. Accordingly, this figure is shown at the intersection of the four lines on the graph in the accompanying figure, which is employed as an aid to the calculation of the weekly earnings balance figure.

The positions of the clock hours and output datum lines in the graph were determined by taking the average of the results of a very large number of calculations, based on clock hours and earnings under the old piece-work scheme. On the horizontal line are shown divisions representing the earnings balance, in increments of 10 per cent on either side of the datum of 107 per cent. The vertical line serves two purposes, in that the divisions thereon can relate either to clock hours or output, each expressed as percentage increases or decreases, above and below the datum point, which in this context represents the average number of clock-hours attended each week in 1954 (the datum year).

An example of the use of the graph is afforded by the dotted line indicated at *A*. Here, it is assumed that output for a given week has risen by 15 per cent, without any increase in clock hours. The line *A* is drawn to the right, from the 15 per cent division, until it intersects the output datum line, whence it is extended vertically downwards—as the line A_1. It intersects the earnings balance line at A_2, which represents a percentage figure of approximately 135. In the example at *B*, however, clock hours have increased by about 11 per cent, without a corresponding increase in output, with the result that the point B_2 is determined by way of the line B_1. The earnings balance is therefore reduced to approximately 86 per cent.

A third example, *C*, shows a combination of the two factors of clock hours and output. Here, it is assumed that the clock hours have risen by about 9 per cent and the output has risen by 15 per cent. The earnings balance is then shown by the point C_2—that is, approximately 120 per cent—by way of the lines *C* and C_1. In this instance, an increased earnings balance is still obtained because although there is a rise in clock hours there is a greater rise in output.

CLASSIFICATION OF WORKING TIME

It is of great importance that any time spent by production workers which is not *directly* connected with increasing the value of the weekly output should be segregated, so as not to falsify the relationship between clock hours and output which is implicit in the graph. To this end, tickets of various colours are issued to direct production workers, as described below.

Purple-topped Ticket

This ticket serves to record "waiting-time," which is claimed by an operator when he is idle for such reasons as: awaiting raw material; machine repairs; awaiting further instructions, etc. The foreman arranges for this ticket to be issued to the operator who records thereon the extent of the idle time and the appropriate reason or reasons, and the ticket is then signed by the foreman. On receipt of this ticket, the cost accounting section excludes the hours thereon from the earnings balance calculations for that particular week.

Yellow-topped Ticket

On this ticket is kept a record of what is termed "extra time," that is, time spent in excess of that allowed for any particular workpiece. For example, extra time required as a result of oversize raw material, additional set-ups, and unplanned operations, is recorded on this ticket. Allowance for this extra time is made by the cost accounting department when calculating the earnings balance.

Blue- and Pink-topped Tickets

Work carried out by an operator which is not connected with the production of a saleable item is considered as "factory expense," and the time

thus expended is recorded on these tickets. Hours spent for this purpose are excluded from the earnings balance calculations by the cost accounting department.

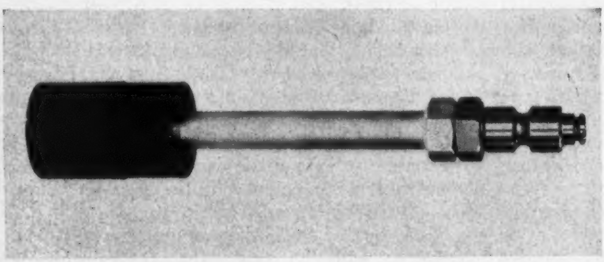
As mentioned earlier, the scheme has been extended to cover all the work's employees, and to facilitate organization, all personnel are allocated to one of three categories. Direct production workers form one group, and receive earnings balances as described above. In a second group are "ancillary workers" who are defined as those providing a direct service to production workers by handling piece parts, but not performing any work on them. Employees in this category are paid a lower percentage earnings balance, which varies weekly according to the number of hours clocked by the group, and according to the earnings balance paid to "direct production" workers.

Finally, there is a third category, comprising "indirect" workers, who are engaged almost entirely on tasks for which the time spent cannot be computed, and who do not carry out a *direct* service to the direct production worker. Workers in this group receive a lower—but directly related—percentage earnings balance than those in the "direct production" group.

Hardcoat Aluminium Air Plug Gauge

Teddington Industrial Equipment, Ltd., Sunbury-on-Thames, Middlesex, have introduced a range of Hardcoat aluminium air plug gauges, one of which is shown in the accompanying illustration. These gauges are relatively inexpensive, and are treated to provide a hard surface which is said to ensure exceptionally long life.

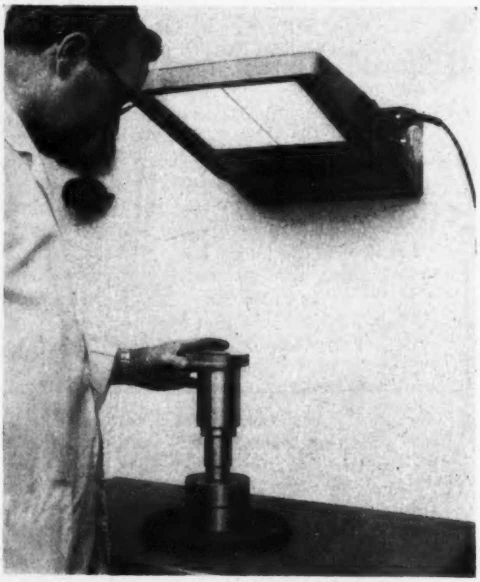
The lightness of these plugs is of particular advantage where large diameter holes are to be gauged. They are available in through and blind hole forms for bores of any depth, and of any size larger than 0·4 in. diameter.



An example from the range of Hardcoat aluminium air plug gauges

Lapmaster Monochromatic Light Unit

Marketed by Payne Products International, Ltd., Slough, Bucks., the Lapmaster monochromatic light



Lapmaster monochromatic light unit

unit shown in the accompanying figure is intended as a light source to facilitate checking the flatness of workpieces with the aid of an optical flat. It incorporates a high voltage transformer, and can be supplied either for bench-mounting, or for fixing to a wall, as shown. The head is pivoted and can be adjusted through an arc of 200 deg. in the vertical plane.

The light source comprises four helium tubes, and the electrical connections are arranged so that a defective tube can be "bridged out" of the circuit, and the unit maintained in use until a replacement is fitted. It is stated that the light can be used for assessing widely varying degrees of flatness.

The unit operates from a 220/240 volts., 50/60 cycles, single-phase a.c. supply, but can be supplied to operate on other voltages to special order.

Polygram 6-station Shell Mould and Core-making Machine

In Fig. 1, a 6-station shell mould- and core-making machine, which has been built by Polygram Casting Co., Ltd., Shernfold Park, Frant, Tunbridge Wells, Kent, is seen in the final stages of erection at the company's No. 2 factory at Tunbridge Wells. Operation of the machine is supervised by two men, and as an indication of the output which can be obtained, it is stated that 100 cores per hour can be produced by the use of single-impression boxes. Smaller cores can be produced in multi-impression boxes at a correspondingly higher output rate, and mould shells are produced, two per station, at a total output of 200 per hour.

The machine has been designed to enable the maximum advantage to be taken of a self-contained manipulator unit, which has been introduced recently by the company, and six of these units are mounted radially on a 12-ft. diameter rotary table. This table is indexed smoothly by an air-operated system, the accuracy of indexing being within 0·004 in. Air-operated plungers provide for locating the table after each movement has been completed, and for positively connecting it to the actuating mechanism while motion is being applied and for locking during the dwell periods.

On each manipulator unit, the halves of the corebox or two pattern plates, are mounted on opposing fixed and moving platens. The moving member is carried on two horizontal cylindrical guide bars, along which it is traversed by means of an air cylinder. For producing mould shells, side plates and a bottom plate are employed in conjunction with the pattern plates, to form an open-topped box when the moving platen is traversed to the closed position.

In operation, any release compound required is applied to the pattern equipment on each manipulator unit at a station at the far side of the table, as viewed in Fig. 1. The moving platen is then closed, and the table is indexed under manual control, to traverse the manipulator to a position beneath a blowing unit, which is mounted vertically on a boom at the right, Fig. 1. Next, the head of this unit is lowered by an air-operated arrangement, and is clamped against register faces at the top of the corebox or pattern plate assembly, as may be seen in the close-up view Fig. 2. Coated sand is then discharged under a pre-set pressure, to fill the cavity, and after a pre-determined period has elapsed, the head is retracted. Of recent design, this blowing unit employs compressed air for discharging the sand, but the arrangement is such that little air is entrained. In this way, turbulence in the cavity that is being filled is almost

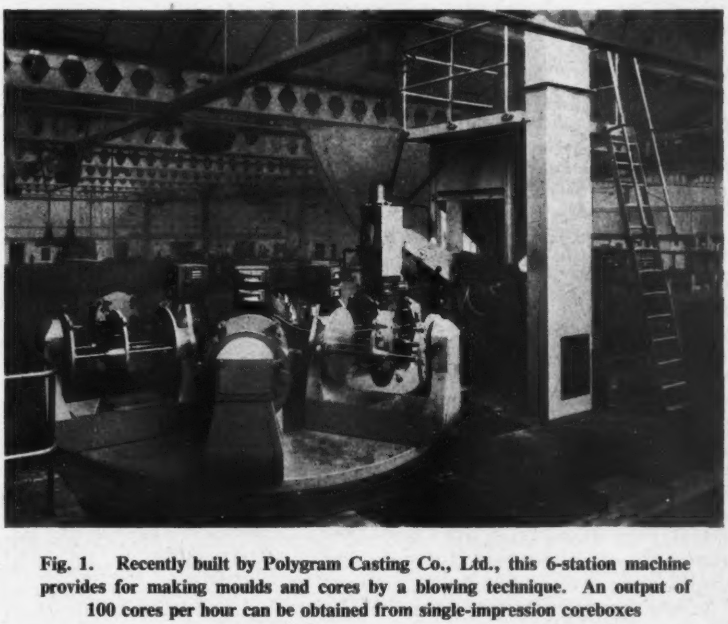


Fig. 1. Recently built by Polygram Casting Co., Ltd., this 6-station machine provides for making moulds and cores by a blowing technique. An output of 100 cores per hour can be obtained from single-impression coreboxes

completely avoided, and there is frequently no need to provide for venting. It is anticipated, moreover, that the use of a blowing technique for producing mould shells will improve the sand density, to obviate the "shadow" effects often encountered when the dump box method is employed.

During movements of the manipulator to the third station, when the table is next indexed, the entire platen assembly is swung through 180 deg., to allow excess sand to fall out. To ensure thorough removal, moreover, the assembly can then be swung several times through a small angle and returned sharply against a fixed stop, to obtain a jolting action. Finally, it is returned to the upper position, in which it is held during subsequent indexing motions whereby the unit is moved successively through the remaining stations, and the period occupied by the latter stages provides time for curing. As the unit approaches the final station in the sequence, the moving platen is withdrawn, and simultaneously, the completed core, for example, is ejected from the box half on the fixed platen. Ejection from the other half of the box occurs only when the moving platen has reached the end of the stroke, in order to allow ample room for removal of the completed core by the operator. Indexing is controlled by this operator, and all the other motions are normally obtained automatically.

Coreboxes, or pattern plates, with overall dimensions of 28 by 18 by 12 in. deep can be accommodated, and the stroke length of the moving platen is 16 in. The core or pattern equipment is heated electrically, a total power of 120 kW. being available, and the individual control equipment on each manipulator unit incorporates two pyrometers, whereby the temperatures of the halves of the corebox, or the plates, are maintained independently within ± 5 deg. of the preset value. The ejector mechanism associated with the platens is controlled by springs, which are housed outside the directly-heated area, to ensure long life.

It may be mentioned that manipulator units can be incorporated on machines with smaller numbers of operating stations, and can also be supplied for use individually, in conjunction with a floor-mounted blowing unit. With the latter arrangement, provision can be made for the employment of two sets of pattern equipment. Blowing can then be performed after the platen assembly has been turned to invert a previously-filled set for removing the excess sand, and additional electrical control gear can be provided to maintain the temperatures of the sets independently.

A sand recovery system is provided for the machine, which is controlled by the second operator, and excess material from the moulding operation passes through openings in the base of each manipulator unit and corresponding apertures in the table. Sand is deposited in an arcuate chute, which is mounted beneath the table and extends between the blowing and the third stations. From this chute, the sand is discharged on to a rubber belt conveyor, whereby it is carried to an elevator, and a grid in the chequer-plate flooring above this unit provides for the introduction of new sand. After being discharged from the elevator, the sand is passed into a hopper, by way of a vibrating screen which serves to remove pieces of partially-hardened material. From this hopper, the sand is delivered to one or the other of two chambers. One chamber, after it has been filled, is pressurized, to supply the small storage space in the blowing unit. When all the sand in this chamber has been used, a transfer valve is operated. The first chamber is then re-filled and the other chamber is pressurized and connected to the blowing unit. This arrangement ensures that sand is constantly available for mould- or core-making.

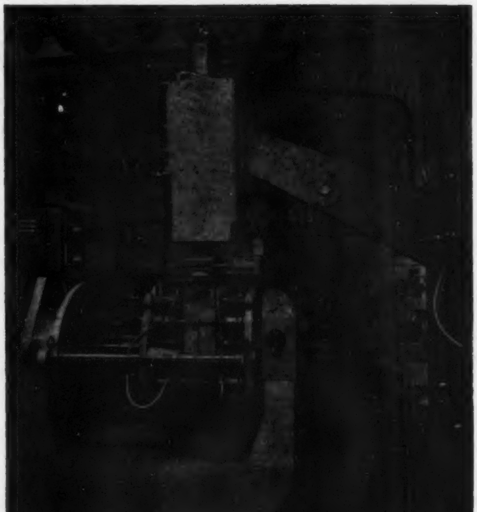


Fig. 2. In this close-up view, the blowing head can be seen clamped against the top edges of an open-top box, formed by opposing pattern plates and side and bottom plates. The pattern plates are carried on opposing fixed and moving platens, on each of six manipulator units mounted on a rotary table

Gating of Aluminium Die Castings

The Second of Two Articles

By H. K. BARTON

In a previous article* some of the basic requirements for the satisfactory gating of aluminium die castings were indicated. The first of these requirements is to maintain stability of flow throughout the filling period. To this end, the runner and gate layout should be such as to avoid (*a*) partial blockage of the gate by chilled metal, which is subsequently cut back by hotter metal so that the gate area varies during the shot; (*b*) the entry, at the beginning of injection, of a metal-air complex instead of a continuous metal stream; and (*c*) atomization resulting from the spraying of the metal into the cavity through a very shallow gate.

If these results are to be achieved, it is essential (*a*) to provide milled runner channels of constant cross-section; (*b*) to avoid sweeps and curves, which promote vorticity and the trapping of air; (*c*) to extend the runners well beyond the gates, or the points at which branch runners leave the main channels, in order to provide pockets for metal and air and so delay the initial passage of metal through the gates until appreciable pressure build-up has occurred and the stream can flow full bore; and (*d*) to direct the flow in such a way as to ensure that the whole cross-section of the cavity is filled at a point as near as possible to the gate, and in particular to avoid the projection of a thin film of metal along one or other of the cavity surfaces prior to filling at full bore. Normally, this requirement entails the use of convergent instead of divergent feeds from the runner to the gate.

RESULTS OF GATING A LONG AND NARROW CASTING CENTRALLY

Following this consideration of generalities in gating practice it is proposed to examine some of the ways in which they can be applied to particular types of casting. As a simple first example, it will be assumed that a plain rectangular plate is to be cast, with measurements of, say, 12 by 1½ by 0·10 in. The volume of such a casting is slightly less than 2 cu. in. and its weight, trimmed, a little more than 3 oz. The gate area required, if the cavity is to fill, as it should, in about 0·020 sec., is 0·10 sq. in., and initially, a cross-section of 2 in. by 0·050 in. is assumed.

In view of the length of the casting, a designer might well consider gating to the middle of one of the sides, to minimize the distance that the metal must travel to fill the cavity. With the assumed

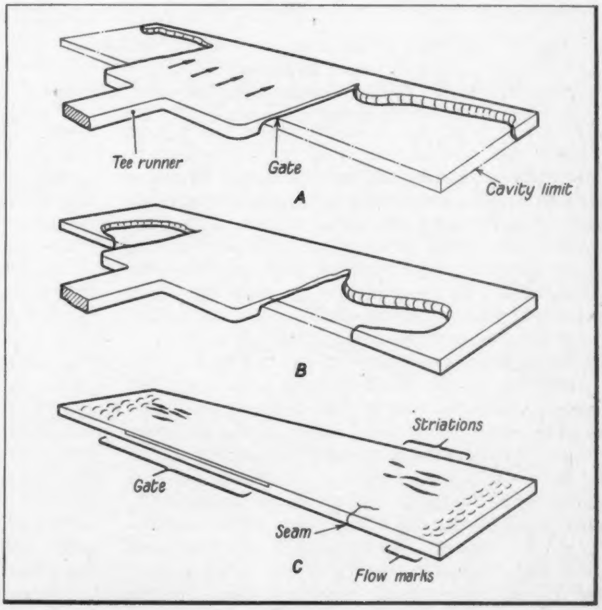


Fig. 1. Sketches showing flow in a thin flat plate. Successive stages in filling are seen at *A* and *B*, and at *C* are indicated the probable locations of defects

* MACHINERY, 99/209—26/7/61.

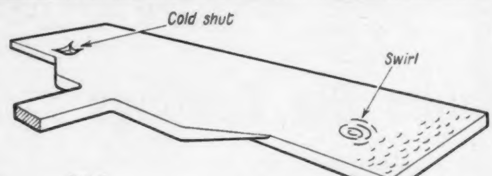


FIG. 2.

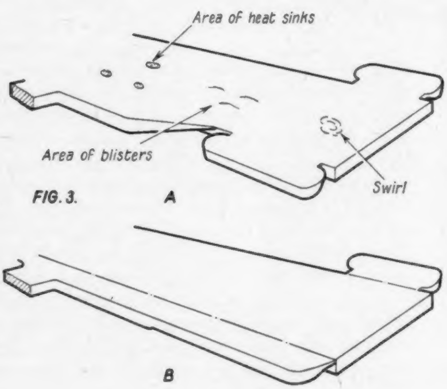


FIG. 3.

Fig. 2. The effect of spreading the gate is to intensify vortex formation

Fig. 3. Some further modifications to the original gating system

ratio between casting thickness and gate depth of 2:1, however, this arrangement is unlikely to be satisfactory because the metal stream, during the greater part of the filling phase, will be projected across the cavity and puddling will occur only on the far side. In consequence, the main spread of metal will be toward the ends of the cavity, but along the ungated side only. An early stage in the filling process is indicated at *A* in Fig. 1.

Spreading of the puddled metal back across the cavity towards the gate is slow, because any build-up at the sides of the metal path tends to be drawn into the stream and again projected forward against the far side of the cavity. As a result, the flow pattern is fairly stable and the metal continues to move along the far side of the cavity until it reaches the ends. Loss of velocity then results in a build up of metal across the width of the cavity at each end, possibly with some movement back towards the gate, as in the sketch at *B*. This slow-moving metal chills quickly. By this time, the greater part of the cavity periphery is occluded and venting has become progressively less effective, so that a pressure build-up occurs in the still unfilled space. The influx velocity then falls and the metal spreads laterally from the area in front of the gate to complete the filling of the cavity.

The general topography of the defects resulting from this method of gating is shown at *C* in Fig. 1. Near the middle of the casting the surface is generally satisfactory, but large areas at each end are glazed and flow-marked, with the edges and corners not sharply defined. Seams occur part-way along the gated side where the metal last injected abuts against the chilled stream. In addition, striations are likely to occur in the areas indicated in the figure, due to the pulsing overlap of successive increments of metal when the cavity was rather more than half filled.

Before turning to alternative methods of gating this casting, it will perhaps be of interest to consider how the layout shown would be modified, nine times out of ten, in an attempt to eliminate the defects indicated. The casting has been shown in Fig. 1 with a parallel-sided feed, and the first step would almost certainly be to double the gate length, by flaring the feed from the existing runner, as in Fig. 2, with the object of projecting metal more rapidly towards the ends, to avoid premature chilling. The effect of this change, however, would merely be to increase the distance that the metal stream, having reached the ends of the cavity, returned along the gated side, and air would finally be trapped between this stream and the metal that later moved outwards from the gated area. According to the temperature conditions, the casting would have either a clear cold-shut, as on the left in Fig. 2, or a surface swirl with large internal voids, as on the right.

The next likely step would be the provision of overflows around the ends of the casting, as at *A* in Fig. 3, to "pull out the air," but since these overflows would fill before the vortices were set up they could have little effect except, possibly, to move the swirls a little nearer to the ends. The increase in the volume of metal passing the gate, coupled with the increased mean temperature of the die, would be likely, however, to result in heat sinks immediately in front of the gate, in line with the main runner, and blisters in the areas adjoining the ends of the gate, where residual air had been trapped

under pressure in the final influx of hot metal as the cavity filled.

The final step would be to convert the overflows on the gated side of the cavity into runner extensions, to provide additional gating, as at *B* in Fig. 3, opposite the vortex sites. This modification would usually disperse the swirls, but only at the cost of ingesting a considerable volume of air in the molten metal, with consequent general porosity and—because of the poor thermal characteristics of the layout—recurrent scattered blistering. The operation of such a die would be critical, since it would be sensitive to small changes in casting temperature, and the scrap rate correspondingly high.

THE IMPORTANCE OF CONTROL OVER METAL FLOW

The shortcomings of the original layout at *A* in Fig. 1 stem from the fact that the designer has little control over the flow of metal within the cavity. Velocity of flow is highly variable both from point to point of the casting and from moment to moment during the filling period, despite the fact that the pattern of flow is reasonably stable. A satisfactory flow is one that is as constant as possible, and with such velocity variations as do occur following a regular and predictable course. This result can only be achieved if the metal stream fills the whole space between the cavity walls throughout the major part of the injection phase. Under conditions of "skin flow"—when the stream is projected in a thin film along one surface of the impression—metal velocity and distance of projection are extremely sensitive to variations in cavity surface temperature.

Under conditions of "free surface" flow, where the metal fills the whole depth of part of the cavity, as in Fig. 1, the velocity is much slower than in skin flow but, again, is very variable, diminishing rapidly as the stream travels further from the gated area, and is markedly affected by the varying temperature of the cavity surface. In consequence, small variations in speed of operation invariably give rise, with either type of flow, to large variations in surface finish and internal homogeneity.

The only type of flow that is in any measure controllable, in fact, is achieved when the metal fills the whole cross-section of the cavity and advances along an unbroken front. In the case of the thin rectangular plate previously taken as an example, a flow pattern substantially of this type is obtained by gating the cavity near one end in such a way as to project the metal stream initially to that end. In other words, the direction of the inflowing stream from the gate should be opposed, so far as is possible, to the direction of mass flow through the cavity.

ADVANTAGES OBTAINED BY GATING A LONG AND NARROW CASTING NEAR ONE END

The nearest approach to this condition that is practicable is depicted in Fig. 4, where a strongly convergent feed from the main runner joins the cavity near one end. The gate terminates about ¼ in. from the corner of the cavity, primarily to leave a datum face to facilitate the grinding of the piece after the gate has been removed, but also to avoid the immediate flow of metal over the end of the cavity as the stream passes the gate. Assuming that the gate area requirement was the same as before, it would be desirable to modify the proportions slightly, and to provide a gate approximately 1⅜ in. long by 0·066 in. deep. This depth is rather more than half the casting thickness, and as the stream from a convergent feed tends in any case to thicken, it is ensured that even at the start of injection the metal does not impinge strongly upon the far wall of the cavity.

With a gate of the type indicated, the metal is projected diagonally to the remote corner, and immediately builds up to fill the gated end completely before advancing along the cavity. Flow

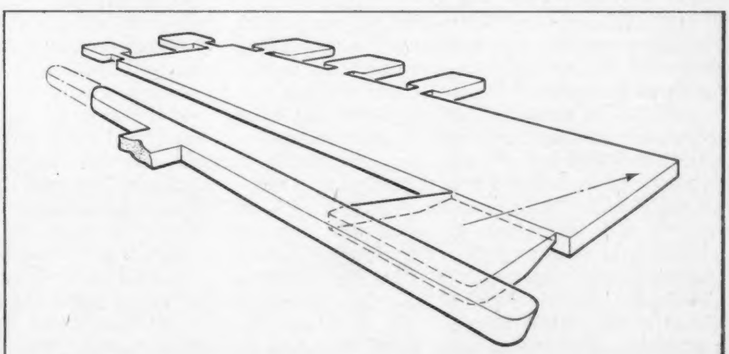


Fig. 4. End-gating, from a main runner extending for the length of the casting, ensures progressive filling from end to end

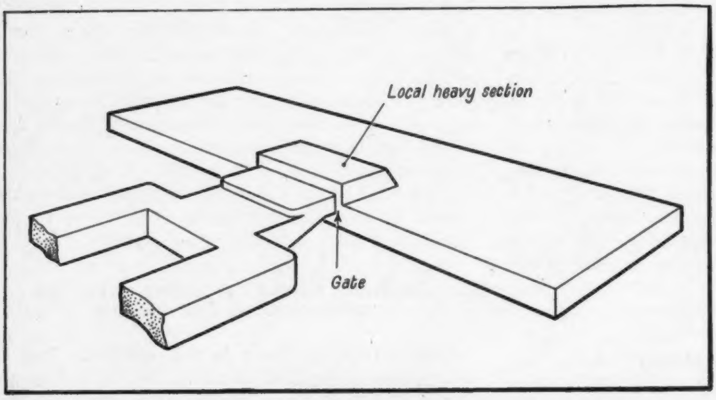


Fig. 5. Where there is a local heavy section in a generally thin web, it is often an acceptable gate location

Metal flowing through the cavity progressively loses heat, with the result that there is a thermal gradient from end to end, but if a blind (ungated) runner is provided as shown in Fig. 4, the steepness of this gradient is much reduced. Nevertheless, it is likely that terminal overflows will be needed to act as additional heat sources and to receive the last of the metal flowing through the section, which, with this gating arrangement, is the coolest. Indeed, it is only when the casting fills progressively in this manner that terminal overflows are fully effective. If a casting is gated as in Fig. 2, the overflows fill long before the cavity itself is filled.

The form of the overflow is important. A single long overflow, gated to the whole length of the end wall, is not desirable, since it affords no control over filling in the last, critical stages. Several small overflows, each of postage stamp size and from ¼ to ⅜ in. deep, are to be preferred. Appropriate positions are indicated in Fig. 4, the variable spacing serving to control the local thermal input. The overflow impressions can be sunk before trials are carried out, but should be left ungated. The volume of metal taken up by terminal overflows should be kept to a minimum, since it is undesirable to delay the final pressure pulse by more than a few milliseconds after filling has been completed.

Since this particular casting has been discussed at length, in order to bring out clearly the factors involved, it must be stressed that the gating to one end is purely an expedient to achieve the desired result, and not a fixed principle to be adopted uncritically. If, for example, the casting was of similar shape and thickness, but with a heavier central pad as indicated in Fig. 5, it would be preferable to feed into the heavy section, from a narrower and deeper gate—about 1 in. by 0·095 in.—instead of to one end. The heavy section would permit an initial build-up of metal, and the stream would then advance, full bore, towards each end of the cavity. Similarly, if there is a heavy section at either end of the casting it should be gated at that end, and if the casting tapers, the gate should be at the wider rather than at the narrower end, to avoid a slowing down of the advancing edge.

is—and continues to be—very turbulent at the gated end of the cavity, but *turbulent flow is not in itself a disadvantage provided that it does not result in the trapping of air.* With the main runner extended well beyond the gate, as shown in the figure, little air is carried in with the metal stream, and air from the cavity space, which is initially ingested in the turbulent metal, is subsequently carried forward as the mass flow progresses along the cavity, and is expelled at the advancing free surface.

Its expulsion is due to the character of flow when the metal fills the cross-section completely as it advances. The rate of advance is, of course, less than the initial gate velocity. In the present instance, where the ratio of the casting cross-section to the cross-section of the gate is approximately 3:2, it might be expected to diminish from about one-half to one-fifth of initial gate velocity as filling proceeds. As the stream moves down the cavity, the metal immediately in contact with the wall surfaces becomes stationary and the layers adjoining the surfaces are much retarded. In effect, therefore, a fast-moving ribbon at the centre of the section is being forced through a sleeve of stationary or slow-moving metal. This central core travels at a higher velocity than the mean at which the mass is advancing along the cavity. Entrained air is thus carried forward and—provided that the cavity is sufficiently long—is expelled into the free space ahead of the metal stream. If, therefore, the runner layout is designed to avoid trapping air that may be carried into the cavity at a late stage in filling—as is liable to happen with some runner systems, discussed in the earlier article—air inclusions in the casting can be largely avoided.

REQUIREMENTS FOR THINNER CASTING SECTIONS

A wall thickness of 0·10 in., as selected for the first example, is typical of a wide range of aluminium die castings, but there is a tendency towards the use of thinner sections, and such sections demand closer analysis. The thinner the section, the greater is the frictional resistance which is encountered within the metal stream when it is flowing full-bore.

Moreover, even a few thousandths of an inch variation in section thickness has a marked effect upon the local flow. With an 0·064 in. section, the gate depth can hardly be greater than 0·045 in., but since the total cross-section area of the gate cannot be diminished in proportion to the reduction in the cross-section area of the cavity, because more rapid filling is needed, the length of the gate must be increased.

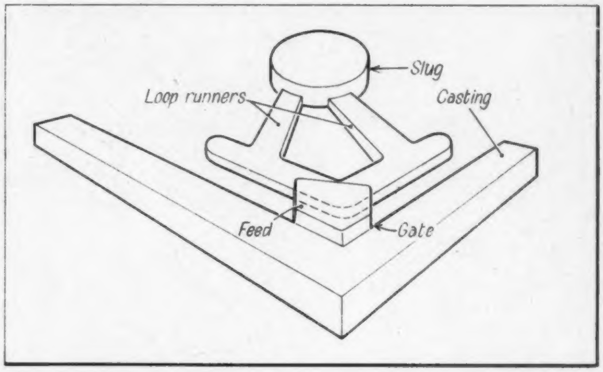


Fig. 7. The arrangement here shown provides for feeding metal to an angle bracket from a position which is located at the inside corner

Long gates, however, are undesirable because they reduce the designer's control over the flow pattern. Preferential flow occurs at those portions of a long gate at which the back pressure of the metal in the cavity is least, and militates against the maintenance of an unbroken front. Thin section castings, if of considerable length, are therefore best fed from a single runner with a multiplicity of gates. Such a layout, for a long, hollow rib, is shown in Fig. 6. Because of the increased frictional resistance in thin sections, it is easier to fill the whole space between the cavity surfaces before the stream has spread very far from the gate, This applies even if the casting is flat, and in the present example the location of the core ensures that the whole cross-section becomes filled. The metal therefore spreads laterally from each of the gates, and the designer's concern is, firstly, to ensure that fusion of adjoining streams occurs before chilling is apparent, and, secondly, to control the flow so that air is not trapped, or, if trapped, is located in positions whence it can be expelled into overflows.

With the casting shown, two main factors affect flow. Initially there is a tendency for the hot metal abutting the core to be forced sideways along the near wall, and this effect is most apparent immediately injection commences. As resistance to flow increases, however, the rate of lateral flow diminishes and more of the metal passes straight over the core to the far side of the cavity. Since local flow through a chilling section tends to become stabilized, the metal thereafter advances preferentially along the far side of the cavity and air is likely to be trapped on the crown of the casting if the gates are close together, and on the near (gated) side if they are far apart. It is for this reason that the main runner is placed at some distance from the cavity with feeding runners leading to the gates. This arrangement permits the provision of overflows of substantial volume (and vented by

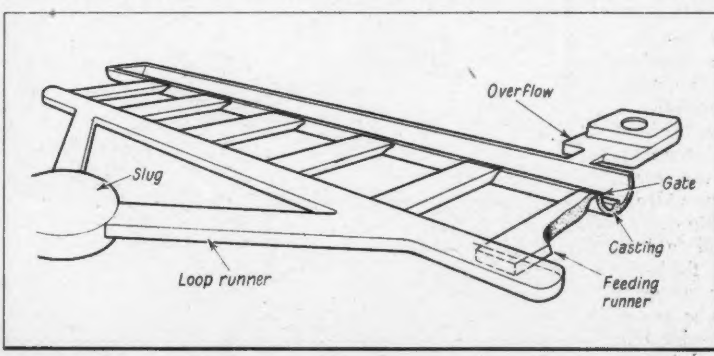


Fig. 6. Method of gating a long, hollow trim strip

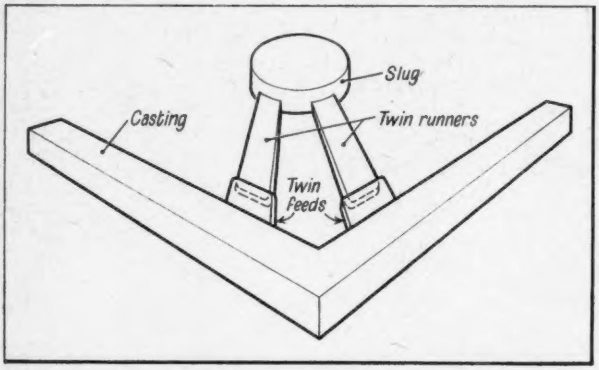


Fig. 8. Twin feeds give a stronger build-up of metal in the corner

large-diameter ejectors) at positions between the gates.

EFFECT OF CORE DISPLACEMENT

In producing castings of this general type it is often helpful, if the tolerances allow, to position the core assymetrically in the section. By increasing the wall thickness on the gated side by, perhaps, 0·005 in., and diminishing the thickness on the other side by the same amount, flow can be preferentially directed along the near side and the points of final fusion are then located on the far side, where overflows can be better placed from the viewpoint of thermal balance. Such a result can only be achieved if the allowable displacement of the core is a substantial fraction of the section thickness. The possibility of controlling flow in this manner underlines the necessity, when producing thin-walled parts of channel or box form, of maintaining very accurate registration of the die blocks.

It will no doubt be evident that, in accordance with the principles already adduced, the appropriate location for the gate on an angle bracket or similar part is on the inside corner, as in Fig. 7. This location gives the desired build-up of metal adjacent to the gate and a mass flow to each end, provided that the casting section is thin—say from 0·080 to 0·010 in.—and fairly even. With castings of thicker section, or if the arms join at an obtuse angle, there is likely to be preferential flow along the outer edge if a single gate is provided, and it is desirable to gate from two parallel runners, as is indicated in Fig. 8.

If the casting is of thin section, on the other hand, the layout should be generally similar to that of Fig. 6, with several gates fed from a single runner. There should be two channels leading from the slug, and arranged to meet the runner opposite ungated portions of the cavity edge. This layout is preferable not only because it avoids heat concentrations, but also because it reduces the distance that the metal must travel along the main runner, which may therefore be of somewhat smaller cross-section.

GATING RECTANGULAR FRAMES

Internal gating of rectangular frames may be regarded as an extension of the method just described. The quite common practice of gating all along one of the shorter inner edges is seldom wholly satisfactory, since it usually results in the projection of the metal stream round the entire periphery of the casting at an early stage of injection. This condition is particularly likely to arise if the outer wall of the frame is thicker than the web. With the external venting thus completely sealed off, there is a sudden build-up of back-pressure within the cavity, the thin-section web fills too slowly, and surface blemishes result.

For a narrow frame, it is preferable to gate to the longer sides near one end, convergent feeds being used to direct the metal back into the corners. A heavy mass of runner metal is avoided by taking a separate runner from the sprue to each of the feeds, as indicated in Fig. 9.

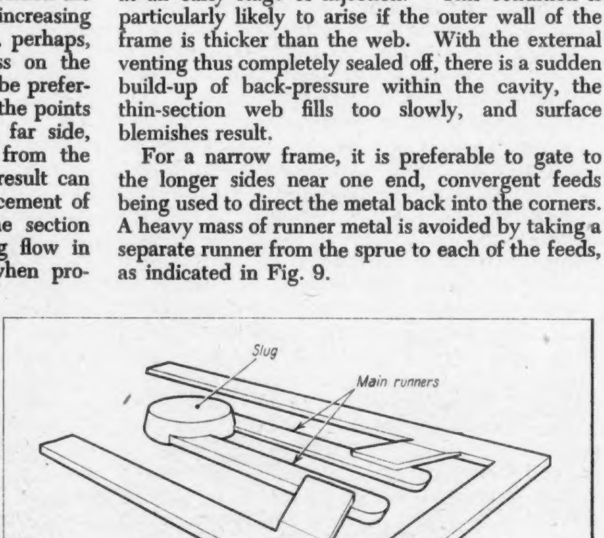


Fig. 9. Internal gating arrangement for a narrow frame

With this arrangement, space is allowed for an internal overflow at the middle of the short side, should it be necessary. For a wider frame, it is desirable to revert to twin gates at the corners. The runners should be carried well into the angles but, again, a central gap should be provided to serve as an overflow, as in the layout shown, in part, in Fig. 10.

These feeding methods are suitable for frames up to about 15 by 8 in. within the normal range of web thickness. It is undesirable to go beyond these dimensions unless the casting is of sufficiently thick section to permit the use of heavier than normal gates—say, 0·100 to 0·120 in. deep—otherwise the filling time is unduly protracted. Larger frames should be fed at both ends, the layout of either Fig. 9 or Fig. 10 being symmetrically repeated. In either case, slight variations at the junction of slug and runners are called for, depending on whether the long axis of the frame is horizontal or vertical. The total cooling contraction with large frames is often sufficient to involve a risk of cracking before the part can be ejected, and it is therefore necessary to make full use of overflow wells to keep up the temperature over the central portions of the longer sides. It is also of assistance if the underface of the frame can be designed with small transverse ribs, at least near the ends of each side, to restrain and localize shrinkage stresses. If normal ribs would cause assembly difficulties, they can be reduced to 0·010-in. high lands, ⅛ or $\frac{3}{16}$ in. wide. Where there are integral rivets or studs, these lands should "bracket" them in order to avoid the introduction of transverse stresses at the roots.

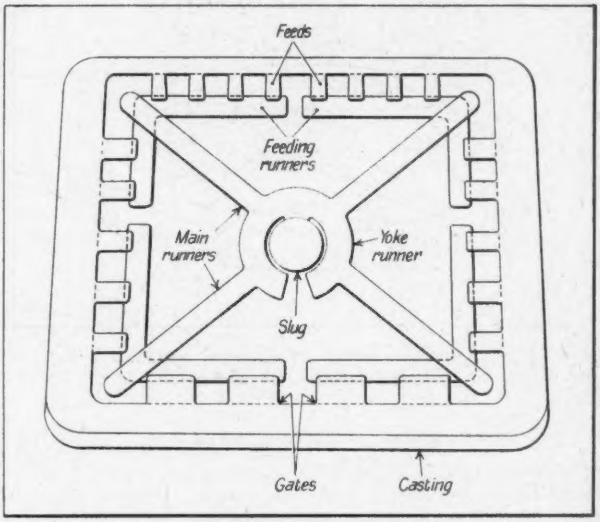


Fig. 11. Runner layout for a frame of thin wall section

Very thin frames should be fed in the same manner as is the casting in Fig. 6, the main runners being carried almost all the way along the inner edges of the casting. A single continuous runner, even if fed by several approach channels, should be avoided, since in practice one or other of the channels may become partially blocked by chilled metal at the start of injection and may later be back-filled by metal that has travelled all round the remainder of the feeding runner.

If the feeding runner is segmented however, as in Fig. 11, the pressure pulse, as the individual short segments are filled and the entry of metal into the cavity begins, is normally sufficient to re-start flow of the molten metal in the approach channel which is partly blocked.

The use of a single approach channel to a continuous loop runner does, of course, eliminate the possibility of this particular trouble, but only at the cost of thermal unbalance and delayed filling at gates on the far side of the loop from the approach channel.

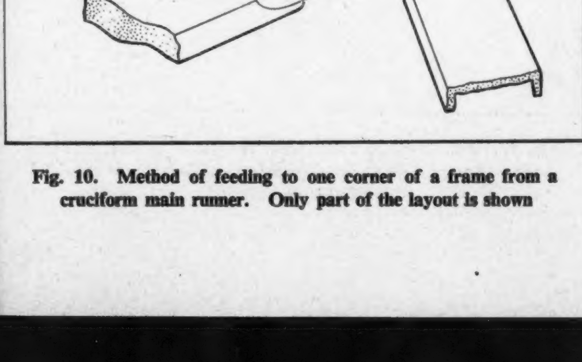


Fig. 10. Method of feeding to one corner of a frame from a cruciform main runner. Only part of the layout is shown

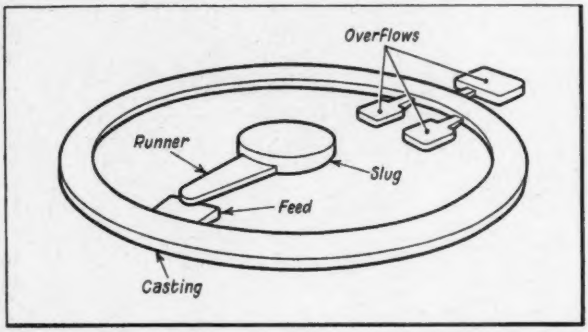


Fig. 12. Internal gating arrangements suitable for a small annular die casting

INTERNAL FEEDING OF CIRCULAR CASTINGS

Internal feeding of circular castings requires even more attention to runner layout, partly because such parts are often decorative or semi-decorative in nature, and must have a particularly good finish, and partly because "free surface" flow is very easily set up in such components and results in internal inhomogeneity. The difficulties are more apparent, however, with large than with small castings. Annular pieces of a size that can be cast on 50- to 100-ton machines with a plunger diameter of 1¾ in. or less, can often be cast satisfactorily with a single convergent feed, in the manner indicated in Fig. 12. The common practice of using a single divergent feed is likely to give rise to blistering in the areas on each side of the gate. Moreover, the excessive mass of metal often involved with a divergent feed tends to reduce the production rate.

A larger annular casting can be adequately fed by two parallel runners if the section is thick enough to allow the use of gates of the order of 0·090 in., and an example is shown in Fig. 13. It will be noted that the runners terminate well short of the cavity and that the feeds, which are somewhat wider but shallower, are sunk in the opposite half of the die. This method is the only reliable one for stepping up the channel width at the approach to the gate. If a widened feed is cut as a continuation of the runner, the side extensions merely fill with dead metal and flow through the gate is divergent and unstable.

Still larger castings can be fed by three or four separate runners subtending, in all some 345 deg. or more, and arranged as seen in Fig. 14. The feeds and gates are located at each end of the various runners. Local flow pattern then achieved is similar to that obtained by the method illustrated in Fig. 13, and the local heat concentration at the T-junction of each runner compensates for the loss of heat in the metal flowing through the cavity towards the zone of fusion. External overflows may, however, be required in addition.

If the casting is not only of large diameter, but also of disproportionately thin section, it becomes necessary to revert to multiple gating, much as in the case of rectangular frames. The greater tendency, with circular parts, for the metal to flow preferentially around the outside edge, however, demands some modification of the orientation of feeds. They should not be disposed radially, but should be tangentially inclined, as in Fig. 15, with the result that metal from the intermediate gates is directed back toward that advancing from the gates near the main runner. In instances where the casting has a number of radially-disposed ribs, the gates should be positioned between such ribs and not in line with them.

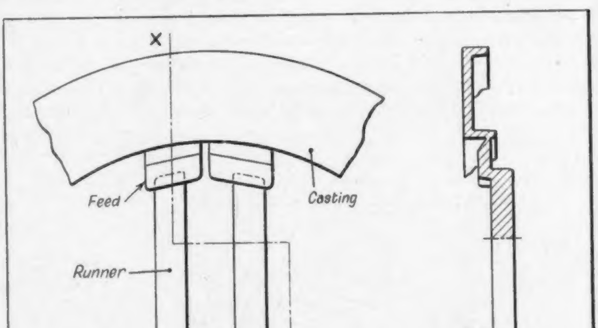


Fig. 13. Paired runners and feeds are used for a larger ring-shaped casting. Additional external overflows may be required with this arrangement

EXTERNAL GATING OF ANNULAR CASTINGS

The external gating of small annular castings presents few difficulties, provided that adequate venting from the centre is maintained. Whatever method of gating is adopted, the areas immediately adjacent to the ends of the gate tend to be the last to fill, and even divergent feeds seldom have any marked deleterious effect, since metal spraying from the extremities is caught up in the mass flow back towards the gate. Nevertheless, it is preferable to avoid such unstable feeds on general grounds.

Single gates are desirable, and for components up to 4 or 5 in. diameter a runner of constant section, radially disposed and connecting with a somewhat wider "underlapped" feed, as in Fig. 16, is generally satisfactory. When parts of this type are cast in multi-cavity dies, the runners should connect with a ring or yoke runner around the slug, in the manner indicated in Fig. 11. One fault that frequently arises with such parts is the occurrence of small air-locks in the lee of countersink cores. This trouble is best avoided by coring the countersink only, and not carrying the core right through the web, the hole being punched out afterwards.

Somewhat larger annular castings, up to 8 or 9 in. diameter, are best fed by a loop runner and—again—a single gate. The gated portion of such a casting is depicted at *A* in Fig. 17. Overflows are required in the central opening, gated to the far side, and on the outside, fairly near to the gate, as shown in the figure. If the central hole is small, twin feeds, as at *B* in Fig. 17, are preferable. Although, by analogy with the simpler parts previously discussed, it might be thought that an annulus of very thin section should be fed from a completely circumferential runner, through multiple gates, such a solution is not sound in practice, owing to the great length of feeding runner required. The best solution is to cast the part in a single-cavity die, with an internal runner system.

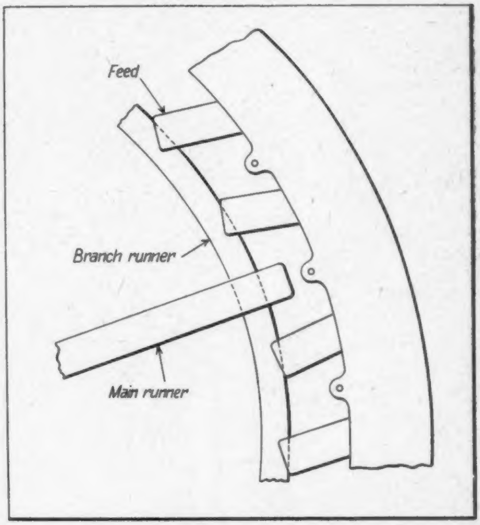


Fig. 15. Multiple gating for a ring of thin section

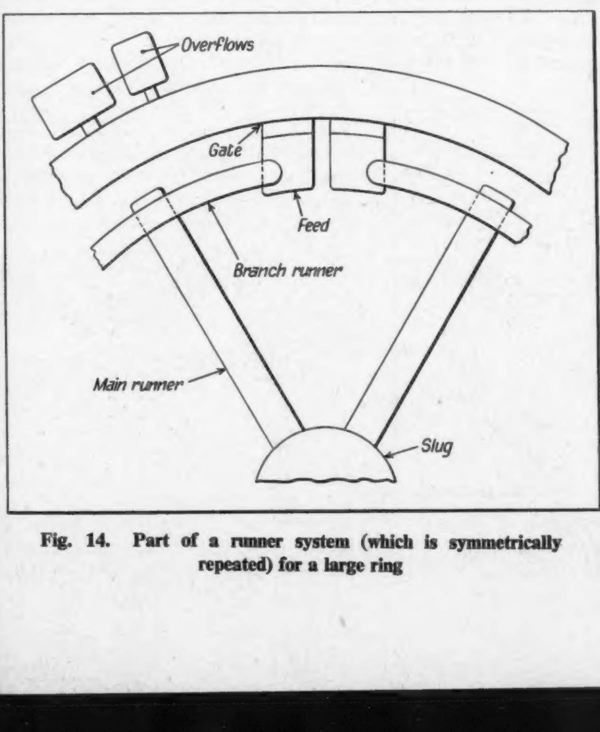


Fig. 14. Part of a runner system (which is symmetrically repeated) for a large ring

GATING DISH- AND CUP-SHAPED CASTINGS

With dish-shaped castings, the primary requirement is to avoid the flow of metal around the outside wall, and to project it well over the crown of the piece to reach the far side. Skin flow along the convex face must, however, be avoided, otherwise air trapped on the under-side of the initially projected skin will form blisters. The only effective solution (apart from feeding at the centre through a solid Polak-type sprue) is to use paired, strongly convergent gates,

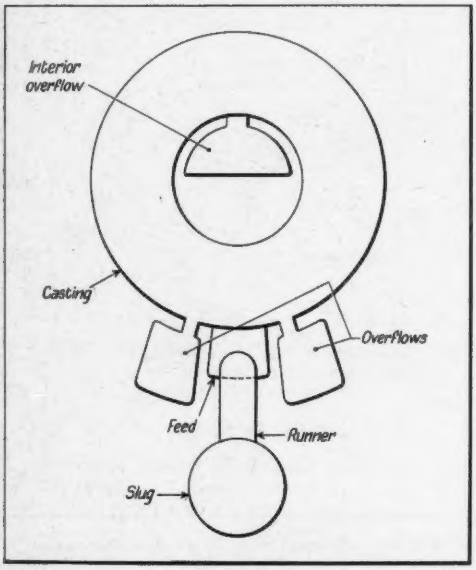


Fig. 16. External gating for a small annulus

as in Fig. 18, to build up the metal to full web thickness as soon as it enters the cavity. It is then projected forward in a substantially parallel-sided stream right over the crown, and thereafter spreads laterally to fill the remainder of the cavity. To avoid overheating of the gate region, the runner should be of as light cross-section as is practicable, and a large number of small (but not shallow) overflows should be provided around the whole of the ungated portion of the periphery. If there are internal radial ribs, some of the overflows should be gated to their ends, but the cavity should be so orientated that the two feeding gates are on either side of one of the ribs. Such a layout can be scaled up and down very satisfactorily, although for small dished parts, cast in multi-cavity dies, single T-runners (Fig. 19), ungated at the centre, may replace the runner form shown in Fig. 18.

Cup-shaped castings, and especially deep cylindrical housings with heavy circumferential flanges at the base, are among the most difficult parts to gate satisfactorily, if only horizontal cold-chamber machines are available. The only completely satisfactory methods, of which there are three, all provide for gating to a point on the top face. The first involves the use of a standard vertical shot-sleeve machine, metal being fed through a slender tapered sprue either to the edge of an internal opening or directly into the web if there is no cored hole or boss on the face. With the second method, a Fries-type sprue-feed is employed, the slug being keyed to the plunger tip (in a horizontal shot-sleeve) and torn away from the tapered sprue as the plunger is retracted. The third method, which can be used with twin-cavity dies, is to feed in the ordinary manner to the back of a movable cavity member and thence by way of tapered sprues to the impressions. The slug and cross-runner are sheared from the back of the die-plate at the end of the first part of the two-stage die-opening stroke.

If it is not practicable to gate anywhere except at the base, the most satisfactory method—assuming that the component is not heavily flanged—is to provide a pair of strongly convergent runners arranged to feed up under the edge of the casting, as in Fig. 20. This illustration shows the gating to one cavity of a 2-cavity die, and it will be noted that the two feeding runners are not disposed equi-angularly to the main runner, which would result in metal entering first through the gate nearer to the slug.

Fig. 17. Arrangements for gating larger rings. A single feed is employed, as at *A*, unless the central hole is small, when paired feeds, as at *B*, are to be preferred

For a larger casting, of perhaps 8 in. diameter, it is inadvisable to rely on a single pair of gates to project the metal right over the crown, and down the other side, before that flowing round the sides meets. Such a casting may therefore be gated on opposite sides, using twin gates as before (Fig. 21). The metal flow is then convergent just inside the cavity,

and the combined streams merge with those from the opposite gates on the top face of the part. Subsequent flow is lateral across the face, the metal spreading downwards along the sides rather slowly to merge with that moving round the wall of the component. Overflows are necessary near the last points to fill, which are roughly equidistant from the gates on each side.

The open nature of the runner layout allows ample space for the location of overflows, but the main reason for positioning the runners well away from the base of the component is to allow a sufficient length of feeding runner to stabilize flow.

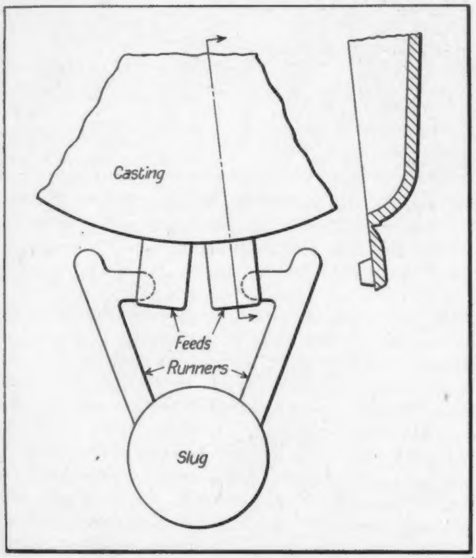


Fig. 18. For a disc or dish-shaped casting, the paired feeds of the previous figure are made more strongly convergent

Unless the length of a branch runner, before it tapers into the feed, is twice to two-and-a-half times its width, turbulence induced by the change of direction results in uneven flow through the gate. It is essential—as in all the other examples discussed—to allow the directionality of flow to become well established in the feeding runner before the gate is reached. It is for this reason that all runners should be milled out to constant cross-section, and not chiselled or ground in with a ball-ended stone. Toolmarks and other irregularities, as well as minor section changes, all add to the instability of flow.

Larger and thinner castings may be gated in the

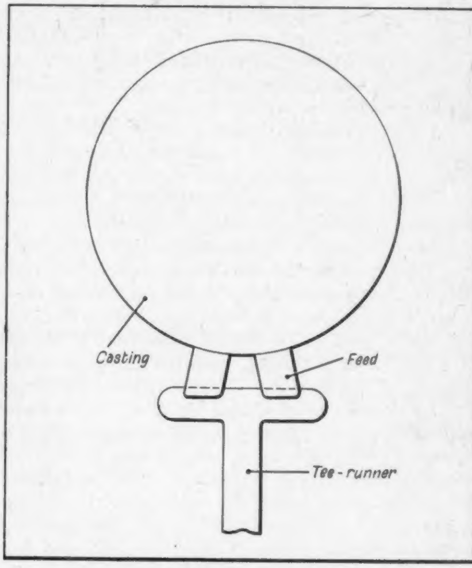


Fig. 19. Simple runner form for a small dish-shaped casting

same manner, using three or even four pairs of gates. In such cases, the branch runners are brought off from a completely annular runner, which should be kept well away from the base of

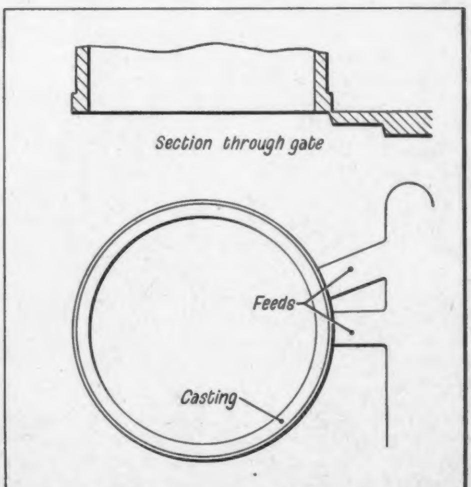


Fig. 20. Gating for a small cup-shaped component

the component even if the use of larger die blocks is necessitated. In practice, many of the troubles encountered in the production of such parts arises from the use of blocks which are so small that the gating possibilities are too limited.

A heavily flanged part presents the further problem that metal can hardly be prevented from flowing preferentially around the flange, and sealing off the cavity at an early stage of injection, if the gates communicate directly with the flange. If the flange section is interrupted by lightening cores, and the gates lead into the heavy sections between, flow is sometimes aided, but the preferable course is to form the face of the moving member with two opposed slides. This arrangement permits the use of a runner surrounding the core and well below the base of the component. The core is shouldered at the cavity intersections so that the gate is approximately at the centre of the section, as seen in Fig. 22. In this case, no attempt is made to converge the flow within the cavity, the metal from the several gates being projected right to the top of the wall to merge on the face. Because the periphery of the flange is not occluded, the flow of metal back down the side walls to the flange, which is the last portion to be filled, is not impeded.

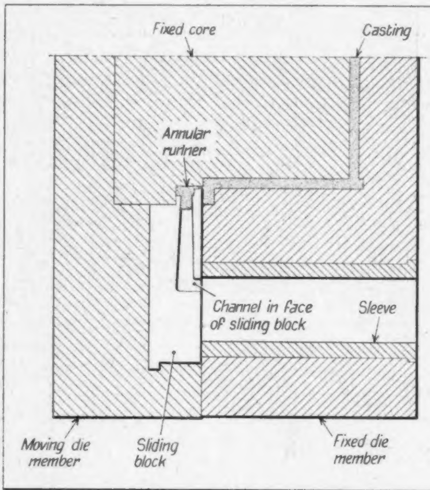


Fig. 22. The use of sliding blocks in the face of the moving die member enables a deep casting to be fed at points well inside the edge of the flange

CHOICE OF SECTION TO BE FED

The choice of a section into which to feed demands care. If there is one localized heavy section in a component that is mainly thin-webbed, it is usually desirable to feed into that section through a heavy gate, the stream then moving out in all directions from the heavy section. If, however, a casting has several local thicker sections, the conditions are different. It is better to feed into the thin web at points between the heavier portions, since fusion of the flows is more likely to be satisfactory if the streams meet where the distance between the cavity walls is greatest. Isolated heavy sections into which it is impossible to gate, however, should not be fed by merging streams, otherwise porosity results. The gates should be located so that such a portion is filled either by the flow from one specific gate or by an already merged joint flow.

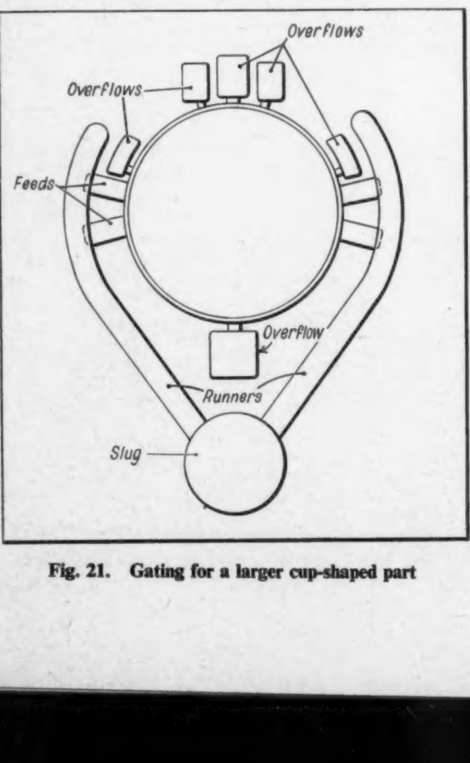


Fig. 21. Gating for a larger cup-shaped part

In feeding long, ribbed castings—such as grilles —it is of even more importance that as much as possible of the air in the runners should be forced through the gates before metal enters, and for this reason close control of the directionality of flow in the runner system itself is necessary. If the ribs are united at the end by a fairly heavy transverse section, the gates should be placed intermediately between the ribs, as at *A* in Fig. 23, but if the transverse section is of no greater cross-section than the ribs themselves, it is better to gate opposite the ends of the ribs, as at *B*. In either case, a cross runner should be cut parallel with the end of the casting, and fed by several channels from the

point of metal entry to minimize the distance of flow along this cross runner. For open-ended grille-type parts, this arrangement is modified as seen at C in Fig. 23.

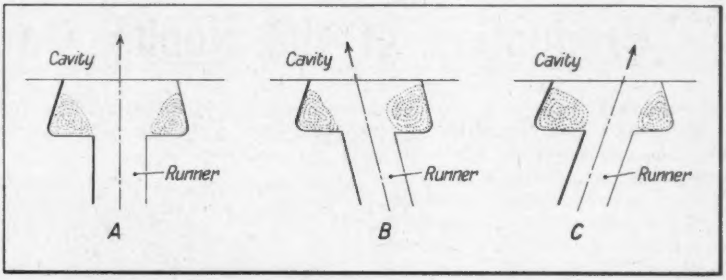


Fig. 24. The angle at which the runner approaches the casting, rather than the detailed disposition of the gate itself, controls the direction of flow as the metal enters the die cavity

GENERAL CONSIDERATIONS

In conclusion, some points of general relevance to all runner layouts may be mentioned. It is of critical importance, when twin gates or multiple gates are provided, that the gate depth should be identical at all feeding points. Friction in the gate area is the main factor which modifies the velocity of metal entry, and if one gate, or a portion of a gate, is even a few thousandths of an inch deeper than the average, metal flow occurs preferentially at this point. If, therefore, a greater volume of metal is required to pass through one gate than through the others, the required result should be achieved by increasing the width, keeping the depth the same as for the remainder.

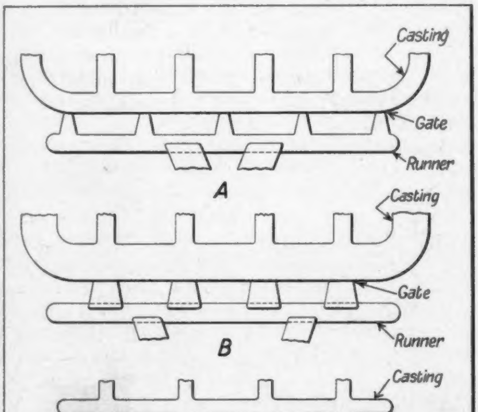


Fig. 23. Runner layouts for ribbed frames and grilles must be suited to the sections into which they feed directly

It must also be borne in mind at all times that, because of the inertia of the fast-moving metal stream, it is the disposition of the feeding runner that determines the direction of flow within the cavity. Thus, with identical gate forms but different runner aspects (Fig. 24), the direction of flow as the metal passes through the gate varies in the manner shown. For example, convergent flow is not achieved merely by cutting the ends of the tapering feeds at appropriate angles. If the runners themselves are divergent, and the cut in the same face as the feeds, the directionality that they impart will determine the path of flow immediately within the cavity, while pockets of dead metal will be formed at the sides of the feeds.

Finally, it must be stressed again that runners should be milled in the die block and should be of constant, substantially rectangular cross-section. Tool-marks should be polished out to minimize the thickness of the stagnant boundary layer within the channel, and thus enable the channel cross-section to be held to a minimum. The aim, throughout, must be to achieve flow conditions in the runner that are least affected by thermal variations in the metal and the die block. Unless this requirement is met, the quality of the castings produced is likewise affected.

B.S.A. Light-weight Engine with Die Cast Cylinder.—B.S.A. Power Units, a division of the Birmingham Small Arms Co., Ltd., Redditch, have introduced a 50-c.c., 4-stroke engine that is designed primarily for lawn mowers. A governed version will also be made for driving pumps and generators, for example. Weighing only 14 lbs., it has an integral die cast aluminium cylinder and crankcase, with a cast-iron liner and valve seats. The cylinder head and crankcase end cover are also of aluminium.

Production of the Hobbs Transmission

Gresham & Craven, Ltd., Walkden, Manchester, a division of the Westinghouse Brake & Signal Co., Ltd., are now well advanced in the planning and layout of a new factory, near their existing Walkden works, which will be devoted to the production of the fully-automatic Mecha-Matic transmission units for motor vehicles, developed by Hobbs Transmission, Ltd., Leamington Spa, Warwicks. An extensive range of standard and special machine tools is now being installed, and it is planned to start flow production early in 1962. Fig. 1 is a view of the exterior of the new factory, which is of modern single-storey construction, with a 2-storey office block at the front, and ample room for expansion. The factory floor area extends to more than 200,000 sq. ft., and Fig. 2 shows the layout table and scale models employed for planning the location of the machine tools, and other equipment.

The Hobbs transmission is a mechanical unit, incorporating an epicyclic gear system with three sun gears. Drive through the system is engaged by hydraulically-operated friction clutches and brakes, to provide four output speeds for forward travel, without the use of a torque-converter. Since the unit is hydro-mechanically actuated, there is virtually no power loss nor increased fuel consumption. Although it is fully-automatic in operation, the Mecha-Matic transmission permits

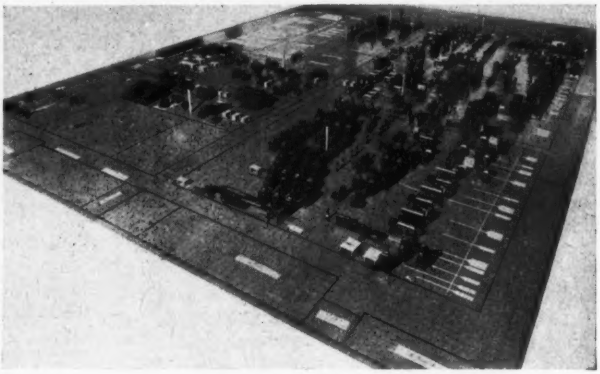
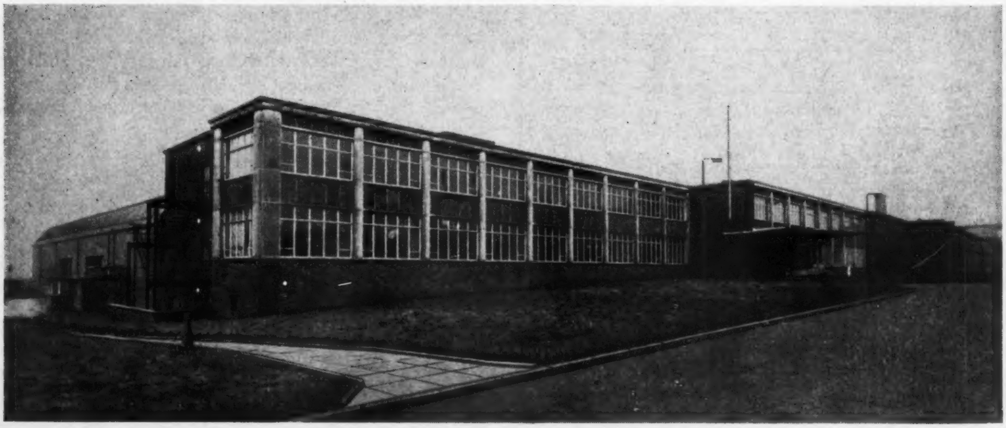


Fig. 2. Layout of the production floor of the new Gresham & Craven factory is being carried out with the aid of the scale models of machine tools and other equipment here shown

Fig. 1. General view of the front of the new Walkden factory of Gresham & Craven, Ltd., which is being prepared for the flow production of Mecha-Matic transmission units developed by Hobbs Transmissions, Ltd.



complete over-riding control by the driver, who may, at will, select and hold any of the indirect gear ratios. However, the design is such that an indirect gear cannot be engaged at a dangerous speed when any of the lower gear ratios is selected manually. The full braking action of the engine is obtained on all four gears, and there is no free-wheeling effect in the transmission under any conditions. The size and weight of the transmission are comparable to those of a normal synchromesh gearbox, and it is stated that service and maintenance requirements have been reduced to a minimum. Mecha-Matic transmission units have been developed to suit engines with capacities from 980 c.c. to 2·5 litres, also for use in light vans and heavy commercial vehicles.

Design of the Mecha-Matic transmission, and the production of two sizes of units, will form the subject of a series of articles to be published in future issues of MACHINERY.

Management Science Advisory Service

SIGMA (Science in General Management), Ltd., 68 Grosvenor Street, London, W.1, is the title of a new organization which has been formed by Martech Consultants, Ltd., and Société D'Economie et de Mathematique Appliquées, France, to provide an advisory service on the investigation of management problems by scientific means. On the staff of this organization there will be experts in various branches of science, who will work as a team in the application of operational research and cybernetics to the problems of industrial and business firms and of Government Departments. The managing director of the company is Mr. Stafford Beer, formerly head of the operational research department of the United Steel Companies, Ltd., and Mr. Roger Eddison, who was the first manager of the operational research section of B.I.S.R.A., is director of operations.

Typically, in carrying out an investigation, the organization would consider what main developments would make the business of a firm more profitable, and would then formulate the possible strategies for such developments as would meet the aims of the management. Next, these strategies would be evaluated in relation to the cost and risk of each, and their vulnerability in the future would be estimated. The means of implementing the best strategies would also be discussed together with the choice of a control system to balance economy with effectiveness. In this way, guesswork would be eliminated, and risks would be analysed and reduced to known quantities.

Addressing guests at a recent reception which was held to mark the formation of SIGMA, Mr. Beer said that the systematic use of science in the solution of management problems had been a recognized activity for 20 years. Under the name of operational research, science had been widely applied to the examination of general-management strategy. This method of approach did not rely on intuition, acumen, or habit, but on the measurement of variables; on the detailed analysis of data; on the measurement of apparent imponderables, such as chance and risk; and on the construction and validation of formal hypotheses. The method involved the employment of a team of scientists who were competent to use available scientific knowledge concerning the way in which large systems behaved, whether they were physical or chemical, biological or social, economic or electronic, anatomic or psychological. Mathematics, statistics, and symbolic logic were utilized.

The potentialities of operational research were not always understood by leaders of the Government and of industrial undertakings, who had not appreciated the scale of past successes. Such research was initiated in Britain during the war, Mr. Beer explained, and was used to plan many strategies. By prescribing the strategy of air attack on submarines, for example, it enabled the number of sinkings, according to R.A.F. records, to be increased by 700 per cent. Now, operational research was used by all branches of the American administration, and in France there was a national economic planning body (Commissariat au Plan) which had successfully organized the economic growth of the country at a rate that was more than double that of Britain. Mr. Beer suggested that the British cotton industry may have been eclipsed for want of an integrated national plan, and wondered whether science could not help to save the British shipbuilders from their sad decline. Judged by international standards, he said, British expansion seemed like decline. Mere exhortations to higher productivity did not produce the required results, and in place of words, full-time constructive work on the solution of our production problems was needed.

The aim of SIGMA was to attack the problems of economic survival, and it was intended to collect as many of the leading personalities in British strategic science, and as many of the best young scientists as would be required to meet the needs of those who used their services.

NEWS OF THE INDUSTRY

London and the South

ALEXANDER BROS., Precision Engineers, Dolphin Works, Catteshall Lane, Godalming, Surrey, are still very busy with orders for precision parts and form tools. The latter, which can be supplied in thicknesses up to 2½ in., are finished on a Wickman optical profile grinder. The Minnow patented miniature tapping attachment with a capacity of 13 B.A. to 2 B.A., which was designed for the production of small threads under conditions of low torque loading, is now in production. With a diameter of 1 in. and a body length of 2 in., excluding the ⅜-in. diameter shank, this attachment is intended for use with capstan lathes and other machines designed for forward and reverse running. A slipping clutch incorporating bearing balls held in recesses under variable spring pressure prevents damage to tap and workpiece in the event of overloading. A sensitive spring-loaded device is incorporated to increase the end thrust on the tap progressively as the torque load rises during operation, to reduce the risk of threads being stripped.

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Darnall Shotblasting Co., Ltd., Sheffield, have a large shot-blasting chamber, in which contract work is undertaken. The steel-walled chamber is 32 ft. long by 12 ft. wide, by 12 ft. high, and is provided with a 20-ft. square extension. In the illustration, shot-blasting is seen in progress on a large gear-wheel casting for Aurora Gearing Co. (Wilmot North), Ltd., Sheffield

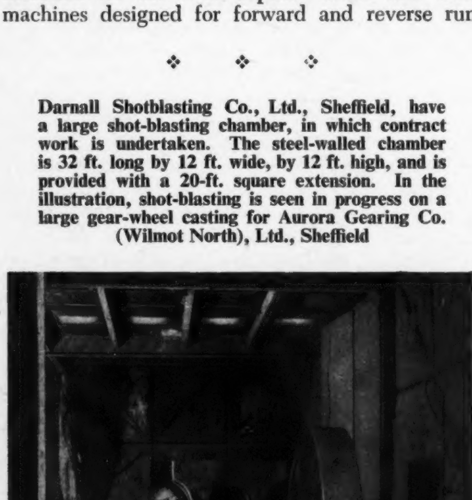


PLATE WORKING MACHINERY LICENCEES, LTD., 42 Broadway, London, S.W.1, report that they have a good order book for various types of plate and section bending rolls built by British and Swiss firms. Much interest is also being shown in tube-bending machines and hydraulically-operated shearing machines made in France, the former by Ateliers Coupé Hugot and the latter by Corpet Louvet & Cie. With this type of tube-bending machine, a cold rolling head inserted in the bore, and located eccentrically, enables a bend of any desired radius to be obtained without the aid of formers. The shearing machines, operating on the Gautron system, are designed to produce square, bevelled, or combined square and bevelled edges in one operation, on plates up to 10 ft. wide. The largest machine in the range, which is suitable for shearing plate up to 1 in. thick, is driven by a 70-h.p. motor and weighs 32½ tons.

NELCO, LTD., Station Road, Shalford, Guildford, Surrey, who are specialists in the design and production of electric motors, report a continued increase in business. A new factory now being built for this company at Farnham, Surrey, will provide additional manufacturing capacity for producing moulded commutators. The space made available at Shalford will be equipped for the production of battery-operated traction motors of improved design, in sizes up to 12 h.p.

E.S.T. (GAUGES), LTD., Lammas Works, Catteshall Lane, Godalming, Surrey, have acquired an additional factory in Godalming, and the total amount of productive floor space at their disposal has thus been increased to 12,500 sq. ft. The demand for Multi-life screw plug gauges, also for plain plug gauges made from tool steel, tungsten-carbide, and Nitralloy continues at a satisfactory level. A growing interest is reported in plug gauges coated with tungsten-carbide, for which purpose equipment by Metco, Ltd., Chobham,

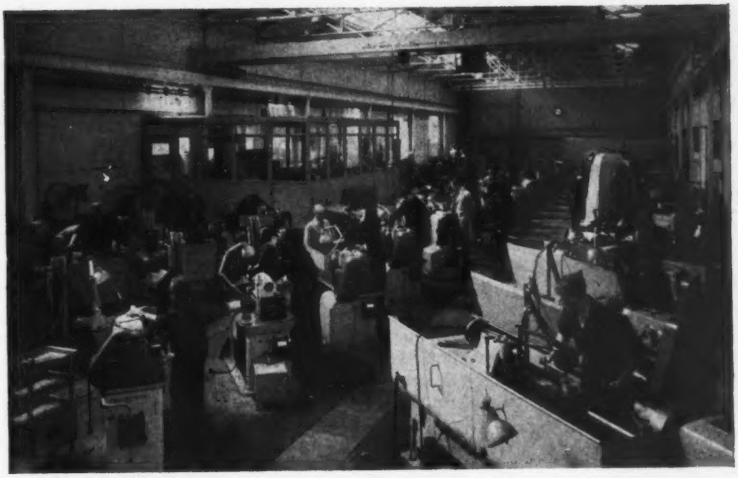
Woking, Surrey, is employed. Such gauges are first built up oversize with tungsten-carbide and then ground to the required dimensions. During the past year the number of machine tools installed in the two works has been increased and we may note that 14 Matrix thread grinding machines are now in regular operation. Internal thread grinding is facilitated by the recent acquisition of a Matrix type 24 machine.

K.S.M. Stud Welding, Ltd., High Street, Woking, Surrey, report increasing interest in various applications of capacitor-discharge stud welding. The process is being extensively adopted, for example, for securing studs to the untreated surfaces of PVC-coated steel sheets without causing burning or discolouration. Studs in a wide range of sizes are now in production, the standard types being made on cold-heading and thread-rolling machines. Traub A 15 and A 25 automatics are employed for special studs and short runs of standard designs. For internally-threaded fittings a 5-spindle Davenport automatic machine is installed. On the contact end of each stud there is a small pip of specified dimensions which disintegrates during the welding process when a current of high amperage and low voltage is passed through it as a result of the discharge of a bank of capacitors in a cycle time of approximately 6 milli-sec. The form of the pip is checked during inspection against a master diagram on a Watson-Manasty Shadomaster projector. A new capacitor-discharge unit designed for operation on 3-phase supply has recently been introduced and may be employed when more rapid capacitor charging is needed for production runs.

F. W. Herridge.

Firth Brown Apprentice School

The new apprentice training school of Thos. Firth & John Brown, Ltd., P.O. Box 114, Sheffield, 4, was recently opened officially by Mr. W. J. Carron, K.S.G., M.A., president of the Amalgamated Engineering Union. A large workshop has been provided, with facilities for training apprentice fitters and apprentice electricians,



A general view in the machine shop of the new Firth Brown apprentice training school

together with a range of modern machine tools for instruction in turning and other machining operations. A general view in this shop is shown in the accompanying figure. There is also a lecture theatre provided with visual aid equipment for talks by instructors and by invited speakers who discuss specialized subjects. Provision has also been made for private study, and cloakroom and canteen facilities are of a high standard.

The first Firth Brown training school was opened shortly after the war and was extended from time to time. It became apparent, however, that complete re-arrangement and provision for training on a larger scale were necessary. It is intended that the boys shall spend 18 months to 2 years in the school, and both general and more advanced specialized training will be given. They will then go to one of the engineering departments, machine shops, or drawing offices where they will be in the charge of other instructors or skilled craftsmen.

Bowmaker Head Office Building

The business of Bowmaker, Ltd., which was established in 1927 with a capital of £10,000 to provide finance for hire purchase and credit facilities, has now become that of bankers, with subsidiaries carrying out the original objects through more than 130 branch offices throughout the United Kingdom. Capital and reserves now exceed £11 million and group assets total more than £80

million. As a result of this rapid expansion, an urgent need arose for more space and the introduction of the most up-to-date equipment and methods at the company's head office building at Lansdowne, Bournemouth.

To minimise interruption of activities, rebuilding has been undertaken in two phases. An extension was first built on a site adjoining the original Bowmaker House, and was completed, ahead of schedule, within 11 months. Subsequently, a major reconstruction of the original building and its integration with the new section was undertaken. The completed building, comprising five floors and a basement, has a total floor area exceeding 94,000 sq. ft. Internal arrangements have been carefully studied in accordance with the requirements of the various sections, and the external appearance is in harmony with the surroundings. The building is mechanically ventilated throughout by a system which, it is stated, has not previously been used in this country.

Wiggin Corrosion Exhibition

"The Fight Against Corrosion" was the title of an exhibition which was recently held in London by Henry Wiggin & Co., Ltd., 20 Albert Embankment, London, S.E.1, to draw attention to the properties and uses of the company's high-nickel corrosion-resisting alloys. Different types of material decay were described, such as pitting, and galvanic, crevice, and inter-crystalline corrosion, and reference was made to the harmful effects of sulphur, oxygen, and carbon materials, for instance, which can result in corrosive reactions. Exhibits included a variety of parts such as springs, chains, bursting discs and holders, pump impellers, pressure-reducing valves, pressure vessels, hose clips, and shell-moulded valve seats, which had been made from Monel, Corronel, and other well-known Wiggin nickel alloys. These alloys, it was pointed out, are available in the form of sheets, plates, strip, bars, wire, and extruded sections, for example.

Concurrent with the exhibition, lectures on corrosion were given, and visitors were able to see four films entitled: "Machining the Wiggin High-nickel Alloys," "Corrosion in Action," "Welding of Wiggin High-nickel Alloys," and "VPT 681—Nickel Tanker." The first-named film emphasizes the importance of correct basic procedure in the successful machining of high-nickel alloys, and the third describes the oxy-acetylene, metallic-arc argon arc, resistance, and flash-butt welding of nickel alloys, and is intended primarily for welders and designers who are already familiar with welding techniques for steel.

Soag Machine Tool Exhibition

Soag Machine Tools, Ltd., Juxton Street, Lambeth, S.E.11, will stage an exhibition of new machines for toolroom and production work at their London showrooms from November 15 to 24 (9 a.m. to 6 p.m.). All engineers interested are invited to visit this exhibition, and in addition to the company's specialists, technical directors and other experts from the works of the various suppliers will be present to give information and advice concerning the latest designs and their applications.

There will be provision for demonstrating all the machines, and we are informed that some of those on view have not previously been shown anywhere. In particular, mention may be made of the Contelyt-Cadet and Contelyt type PH 175 electrolytic grinding machines for sharpening carbide tools by the electro-chemical process. These machines are built in Switzerland by Maschinenfabrik Aargau and each has a generator of the company's design built into the base. In this way, it is stated, simplicity and high efficiency have been achieved.

Other exhibits will include an Ajax radial drill; two Elb surface grinders, one of which will be a type SWD 20 of 79- by 29½-in. grinding capacity; a Hoerster rotary surface grinder; two Mondiale production lathes; a Schaerer super heavy duty sliding, surfacing, and screw-cutting lathe; a universal miller and a universal tool and cutter grinder by Pedersen; a Wotan type B 130 K floor type horizontal borer; Sala cutting-off machines; a range of Dansk power presses from 24 to 100 tons capacity; a Skandia 8-ton power press; a range of Hydromatic air presses; a range of Scantic plate bending rolls; an M.R. & P-Torrington spring coiling machine; and various Ortlinghaus clutches and gear units.

Machine Tool Fair in Japan

A Japan International Machine Tool Fair (JIMTOF), organized by the Osaka International Trade Fair Commission, will be held in Osaka, from October 10 to 21, 1962. Supported by the Ministries of International Trade and Industry (M.I.T.I.), Foreign Affairs, and Finance, and the Japan National Railways, the Fair is sponsored by various Japanese associations concerned with machine tool building and importing, and the making of metal-forming machines, small tools, carbide tools, industrial diamond tools, measuring instruments and grinding wheels. Exhibits will include Japanese and foreign metal-working machine tools, presses, die casting machines, sheet metal-working equipment, machine tool accessories including gauging and loading and unloading units, precision measur-

ing instruments, grinding wheels and materials, and other production equipment.

The cost of renting a stand unit measuring 3 by 2·5 metres (9·8 by 8·2 ft.) is approximately £100, and applications have so far been received for some 1,600 stand units (128,000 sq. ft.) from Japanese firms, of which 860 have been booked by members of the Japan Machine Tool Builders' Association. To date, the numbers of applications received from some other countries are as follows: West Germany 247, U.S.A. 240, United Kingdom 227, Switzerland 109, Italy 105, France 94, East Germany 64, Czechoslovakia 22, and Poland 22. The total number of stand units so far booked by non-Japanese firms is 1,200 (96,000 sq. ft.).

The address of the Osaka International Trade Fair Commission is Honmachibashi, Higashi-ku, Osaka, Japan (cables, Nipponfair Osaka), and the Commission also has a Tokyo office, c/o Trade and Tourist Centre, 3rd floor, Kokusai Kanko Kaikan, 1, Marunouchi 1-chome, Chiyoda-ku, Tokyo.

Obituary

Mr. Gaston E. Marbaix. We regret to report the death, on the evening of October 17, of Mr. Gaston E Marbaix, managing director of Gaston E. Marbaix, Ltd., Devonshire House, Vicarage Crescent, London, S.W.11, and very well known as an importer and builder of machine tools. He established his machine tool importing business in 1915 and had represented, in this country and abroad, many of the foremost builders in the U.S.A. and Europe.

During the second world war, his company was one of the few importing firms appointed by the Ministry of Supply to handle American machine tools and the distribution of small tools under the Lease/Lend scheme. In addition, the services of the company were enlisted by the Ministry in connection with the United Kingdom re-armament programme of 1949 for the importation of important American machine tools.

A few years ago, Mr. Marbaix took over a factory in South West London and started the production of machines and equipment. With the continued expansion of the business, he formed the associated companies, Automation, Ltd., Marbaix Industries, Ltd., Henry Challis, Ltd., and Spotnails, Ltd., each of which is concerned with a particular specialized section.

Although suffering from the effects of a breakdown in health which occurred nearly five years ago, Mr. Marbaix, characteristically, continued to take an active part in the business until within four or five weeks of his death.

Mr. G. E. Marbaix

New Appointments

Mr. J. E. Swainson and Mr. A. S. Moseley, as directors of Permale, Ltd., 125 Bristol Road, Gloucester.

Mr. J. T. Davenport as general manager of Sheepbridge Equipment, Ltd., Foundry Division, Chesterfield. He has been succeeded as foundry manager of Sheepbridge Alloy Castings, Ltd., Sutton-in-Ashfield, by Mr. W. McLelland.

Mr. G. H. Woods as sales and commercial manager of Thomas Chatwin & Co., Great Tindal Street, Birmingham. He has had some 30 years' experience in the small tools industry, and was formerly commercial manager of the B.S.A. Small Tools Division.

Sir William Strath, K.C.B., Mr. W. Hackett, Jnr., and Mr. R. D. Young, as managing directors of the Tube Investments Group, The Adelphi, London, W.C.2. Sir Ivan A. R. Stedeford, G.B.E., has relinquished the post of managing director, but will continue to hold the office of executive chairman.

Mr. E. Crisp, as general sales manager of Aerostyle, Ltd., Sunbeam Road, North Acton, London, N.W.10. He started work as a warehouse assistant and messenger boy and has completed 35 years' service with the company. During this period he spent considerable time in the production shops, was an outside fitter and demonstrator, and assistant foreman of the fitting department. Later he was in charge first of the London showrooms, and then of the order department and despatch stores at North Acton. For the past six years he has been handling sales of the full range of Aerostyle equipment.

Microfilm Edition of Machinery

Machinery is obtainable on microfilm from University Microfilms, Ltd., 44 Great Queen Street, London, W.C.2. It is reproduced on 35-mm. unperforated microfilm stock, and only a complete year's issues (2 volumes) can be supplied. All pages published, advertising as well as editorial, are filmed, and one year's issues are accommodated on three 100-ft. reels and occupy a space of 4 by 4 by 5 in. (80 cu. in.). The price of the issues for one year depends upon the number of pages published, but as an approximate indication it may be noted that the issues for 1958 are obtainable for £12 13s. 6d.

Holes for Wire Thread Inserts

British Standard 3409:1961 is concerned with the tapping of holes to receive wire thread inserts (for UNC and UNF threads). Limits are given for the sizes of tapped holes which, when inserts are assembled, will give the nominal sizes and tolerances for the required internal Unified threads. There are also recommendations for suitable screwing taps and gauges. It has not been considered practicable, at present, to standardize the inserts, as the free forms depend on the method of manufacture.

Copies of the specification may be obtained from the British Standards Institution, Sales Branch, 2 Park Street, London, W.1. (Price 7s. 6d., postage extra to non-subscribers.)

Industrial Notes

SIMMONDS AEROCESSORIES, LTD., Treforest, Glamorgan, have introduced a range of precision forged self-locking nuts of the Nyloc type. Nuts of this type are at present available in full and thin forms, in sizes from ¼ to ½ in., with Unified fine threads.

DEXION, LTD., Maygrove Road, London, N.W.6, have introduced a new range of steel shelves with dimensions of 36 by 12, 18, 24, 30, and 36 in., and in different strengths. The two narrowest shelves are available in light and standard gauges, the two widest, in standard and heavy gauges, and the 24-in. width, in all three strengths.

CASATI ERNESTO & FIGLI, CASER S.p.A., Pavia, Italy, inform us that the agents for their machines in England are Herbert Widdowson & Sons, Ltd., Canal Street Works, Nottingham, and in Scotland, Henderson & Keay, Ltd., 189 Pitt Street, Glasgow, C.2. Reference was made to the company's radial drilling machines, as shown at the Brussels Exhibition, in MACHINERY, 99/541—6/9/61.

SPARCATRON (MANUFACTURING), LTD., is the title of a new subsidiary company which has been formed by the Universal Grinding Wheel Co., Ltd. The new company has occupied a factory at Tuffley Crescent, Gloucester, specially designed for the manufacture of Sparcatron machines, which were previously made by another subsidiary, Impregnated Diamond Products, Ltd.

TRAINING COURSE IN WORKS MANAGEMENT.—A second "split full-time" training course leading to the certificate in works management and to graduate membership of the Institution of Works Managers, 196 Shaftesbury Avenue, London, W.C.2, will open at the Technical College, Hendon, London, N.W.4, on November 6. This course involves two periods of full-time training, each of 4 weeks' duration, separated by an interval of 6 months.

INTERNATIONAL COMPUTERS & TABULATORS, LTD., Gloucester House, 149 Park Lane, London, W.1, have concluded an agreement with the Radio Corporation of America for the non-exclusive exchange of technical information and patents in the field of data processing. The substantial research and development activities of I.C.T. will continue, and it is anticipated that progress in these fields will now be extended and accelerated as a result of the new agreement.

ASSOCIATED BRITISH MACHINE TOOL MAKERS (INDIA), LTD., P.O. Box 2050, Temple Chambers, 6 Old Post Office Street, Calcutta, 1, and ASSOCIATED BRITISH MACHINE TOOL MAKERS (PAKISTAN), LTD., 14 Metropole Buildings, Victoria Road, Karachi, 17, have recently been appointed distributors in India and Pakistan, respectively, for the Lapointe Machine Tool Co., Ltd., Otterspool, Watford By-Pass, Watford, Herts., and the Lapointe Machine Tool Co., Hudson, Mass., U.S.A.

MOON BROTHERS, LTD., Beaufort Road, Birkenhead, Cheshire, builders of plant for steel drum manufacture, have just completed an extensive factory modernization and expansion programme. The alterations provide an extra 4,200 sq. ft. of floor space, making a total of approximately 75,000 sq. ft., and the company's labour force will probably be increased by about 20 per cent. A new frontage and office block have been provided, in addition to the increased factory space. In 1960, 66 per cent of the company's output was exported.

ALLEN WEST & CO., LTD., Brighton, 7, have acquired the factory premises at Newtownards, Co. Down, Northern Ireland, formerly occupied by Lee Guinness, Ltd. This recently-built factory has a total area of 56,000 sq. ft. and there is ample space for expansion. In addition, the company has purchased most of the plant. Assembly and wiring of Allen West contactor panels will be undertaken, and continuity of employment will be offered to existing factory workers. It is anticipated that in three to four years the number of employees will rise to about 400.

COURSES IN APPLIED MECHANICS.—University of Sheffield, Postgraduate Department of Applied Mechanics, Mappin Street (St. George's Square), Sheffield 1, have issued particulars of various courses to be held during the period ending June, 1962. Subjects include, for example, analogue computing methods for engineers; mechanical vibration; analysis of failures of machines and structures; stress determination; fine measurement in mechanical engineering; gear design; and hydraulic operation and control of machines. Duration of courses ranges from 4 days to 5 weeks.

EDWARD PRYOR & SON, LTD., Broom Street, Sheffield, 10, have registered a new company with the title Edward Pryor Developments, Ltd., to design automatic marking machinery and auxiliary equipment. The board of the new company comprises Mr. G. R. Pryor, Hon. M.I.Prod.E. (chairman), Mr. A. Throp, M.I.Mech.E., F.B.I.M. (managing director), and Mr. A. E. Godbehere, A.Met., A.I.M. Mr. Throp remains on the board of Edward Pryor & Son, Ltd., but has relinquished his executive position, and has been succeeded as deputy managing director by Mr. C. Ellis, A.M.I.Mech.E., M.I.Prod.E.

THE NORTHERN IRELAND INDUSTRIAL DEVELOPMENT SCHEME.—A total of more than 100 factories and extensions, ranging in area from 2,000 to 75,000 sq. ft. has already been completed by the Northern Ireland Ministry of Commerce under their Industrial Development Programme, and it is stated that over 50 additional building projects are in hand. Factories and extensions already built, or in progress, now total more than 8,000,000 sq. ft.

The first advance factory to be built under the scheme was occupied in 1948 by International Computers and Tabulators, Ltd., and occupied an area of 50,000 sq. ft. Now, the company has premises on the same site which provide more than 500,000 sq. ft., and the number employed is 2,750. By January of next year it is hoped that the latter figure will have risen to 3,000.

Machine Tool Exports and Imports

EXPORTS OF MACHINE TOOLS

Type of Machine	Month ended July 31, 1961 Value £	Seven months ended July 31 1960 Value £	Seven months ended July 31 1961 Value £
New, complete—			
Bar and chucking automatics	69,047	425,894	604,660
Boring machines:			
Vertical	54,525	252,311	624,124
Other	75,889	883,528	600,977
Drilling machines	92,919	771,213	817,787
Gear-cutting machines	74,159	544,673	605,409
Grinding, lapping and honing machines	295,377	1,517,367	2,086,825
Lathes:			
Capstan and turret	194,395	1,261,121	1,756,476
Other	446,818	2,260,511	2,621,585
Milling machines	412,757	1,260,165	1,891,319
Planing machines	6,276	126 022	224 175
Presses:			
Hydraulic	209,713	579,661	725,995
Other	70,723	1,632,670	752,687
Punching and shearing machines	38,048	331,366	414,690
Other plate and sheet-metal working machines, including straightening rolls	79,350	389,143	483,899
Screwing and threading machines	46,857	459,713	515,643
Shaping and slotting machines	29,710	234,877	259,145
All other machines	246,657	1,474,494	2,003,014
Used, complete	62,618	768,640	486,547
Parts	288,412	1,719,554	2,292,388
Total	2,794,250	16,892,923	19,767,345
Destination			
India	310,712	1,998,560	2,713,389
Australia	215,841	3,825,868	2,530,794
New Zealand	60,544	250,786	511,034
Canada	162,392	842,362	918,653
Other Commonwealth countries	122,912	923,562	1,058,893
Union of South Africa	79,903	744,737	875,988
Soviet Union	48,378	227,031	538,227
Sweden	65,821	380,305	665,302
Western Germany	217,476	562,085	1,133,535
Netherlands	72,690	344,583	498,392
France	199,927	908,994	975,075
Spain	73,975	289,813	564,693
Italy	226,557	434,169	1,420,869
United States of America	75,003	1,572,375	717,764
Other foreign countries	862,119	3,537,693	4,644,737

IMPORTS OF MACHINE TOOLS

New, complete—			
Bar and chucking automatics	74,199	325,339	575,075
Boring machines	162,809	885,353	940,399
Drilling machines	45,731	177,686	279,419
Gear-cutting machines	60,403	410,445	1,234,404
Grinding, lapping and honing machines	323,716	2,474,126	2,738,299
Lathes	453,465	1,263,154	2,181,122
Milling machines	423,095	1,627,142	2,093,910
Planing, shaping and slotting machines	14,277	237,616	356,336
Presses	156,674	882,331	1,178,146
All other machines	321,927	2,233,194	3,509,273
Used machines, complete	63,964	693,488	496,211
Parts	325,959	1,848,895	2,267,108
Total	2,426,219	13,058,769	17,849,700
Country of Origin			
Western Germany	690,158	3,827,577	5,063,870
Switzerland	353,204	1,872,332	1,971,541
U.S. America	776,447	5,128,350	7,087,698
Other countries	606,410	2,230,510	3,726,591

MANUSCRIPTS FOR BOOKS covering all branches of engineering production will receive careful consideration and should be sent to the Manager, Book Dept., MACHINERY, National House, 21 West Street, Brighton, 1.

Trade Publications

JAMES GORDON & CO., LTD., Dalston Gardens, Stanmore. Folder describing the Konitest dust meter, for indicating—and if required recording—quantities of dust particles in air or gas.

RAPID MAGNETIC, LTD., Lombard Street, Birmingham, 12. Leaflet describing the range of Dreadnought lifting magnets. Separate sections are concerned with cable reeling drums and contactor controllers.

IMPERIAL ALUMINIUM CO., LTD., P.O. Box 216, Witton Birmingham, 6. Brochure devoted to Impalco aluminium alloy treadplate which is available in two designs. Information is included on maximum loads, and typical applications are illustrated.

STURTEVANT ENGINEERING CO., LTD., Southern House, Cannon Street, London, E.C.4. Publication No. 2605, which supersedes No. 2604, gives full information on the company's range of paddle-bladed D fans, with numerous diagrams and half-tone illustrations.

EUCO TOOLS, LTD., 44 London Road, Kingston, Surrey. Folder giving particulars of Euco engraving cutters which can be supplied in high speed steel or with carbide tips, and with straight or taper shanks. Other items listed include hard brass line copy, driving belts, rotary tables, indexing and dividing attachments, grinding wheels, and filling wax.

P. P. PAYNE & SONS, LTD., Haydn Road, Nottingham. Brochure devoted to the company's range of specialized packaging and labelling products which include, for example, reinforcing and banding tapes, tensioning tools, seals and floor dispensers, self-sealing strapping and tear-tapes, plain and printed polythene bags, bag sealing tapes and dispensers and tying tapes.

ALBRIGHT & WILSON, LTD., 1 Knightsbridge Green, London, S.W.1. Publication entitled "Survey of a Chemical Group," which is noteworthy for the high standard of presentation maintained throughout. It extends to 72 pages and includes sections concerned with the companies in the Albright & Wilson Group, the technical and commercial resources of the Group, the main products, of the Group, and historical notes.

STONE-PLATT INDUSTRIES, LTD., Oceanic House, 1a Cockspur Street, London, S.W.1. Illustrated guide, of 72 large pages, indicating the products and services offered by companies within the Group. Following a brief history of the organization, sections are devoted to marine engineering; mechanical, electrical, and electronic engineering; textile machinery; overseas companies; and associated companies. Indexes to the products and services, in four languages, are included.

RADIOVISOR PARENT, LTD., High Path, London, S.W.19.—Illustrated leaflet drawing attention to various types of control panels which have been supplied for flame failure detection, smoke density indication, conveyor control and batch counting, weld timing, boiler control, and cordite press control, the latter being arranged to operate a cooling system should the cordite become heated.

THE DIAMOND SCREW & COTTER CO., LTD., Cherrywood Road, Bordesley Green, Birmingham 9.—Leaflet showing the various types of repetition precision parts which the company is equipped to produce. Specialties include brass turned parts and inserts for the electronic plastics moulding industries, high-tensile steel studding in diameters up to 1 in. and lengths exceeding 12 in., link pins and yokes, form-turned parts, and split or solid standard taper pins.

THE CASTLE ENGINEERING CO. (NOTTINGHAM), LTD., Haslam Street, Castle Boulevard, Nottingham.—Folder giving details of the contract repetition work that can be undertaken, the plant including automatics from $\frac{1}{4}$ to $2\frac{5}{8}$ in. capacity, and capstans up to $4\frac{1}{2}$ in. capacity for bar work, and 13 in. diameter for chucking. The company is associated with the Midland Bright Drawn Steel Group.

FERRANTI, LTD., Hollinwood, Lancs. Exceptionally well produced publication entitled "A Review of Ferranti Activities, 1961," with numerous illustrations, including some in full colour. Following a personal message from the managing director, there are sections devoted to transformers and associated equipment; insulation; electricity meters; foundry; measuring instruments; computers; Scottish group of factories; electronics; "Bloodhound," aircraft equipment, and fire control; and overseas subsidiaries.

GISHOLT MACHINE CO., Madison 10, Wis., U.S.A. (Wickman, Ltd., Fletchamstead Highway, Coventry). Fully-illustrated 20-page catalogue describing the Masterline Type S dynamic and static balancing machines which are designed for balancing parts weighing from one to 300 lb. Specifications are given for the eight machines in the range, and particulars are included of various accessories that can be provided, for example, drilling equipment for removing metal, and a spot or projection welding unit for adding metal, to achieve balance. Facilities for balancing at speeds up to 12,000 r.p.m. can be provided. A number of typical applications of the machines is shown.

BROOKE TOOL MANUFACTURING CO., LTD., Warwick Road, Greet, Birmingham 11.—Comprehensive illustrated brochure of 34 pages dealing with the firm's range of gear pumps. The Warwick pumps, made in $\frac{1}{4}$ and $\frac{3}{8}$ in. gas sizes, are intended for coolants, and the Brooke range, available in seven sizes from $\frac{1}{4}$ to 2 in. gas, are suitable for force-feed lubrication systems, and have been used, with suitable modifications, for pumping liquids as varied as paint, silicone fluids, fuel oils, diesel oils, tar, and ink. Brooke reversible pumps are also available, together with pumps in sizes of $\frac{3}{8}$ and $\frac{1}{4}$ in. gas, which are capable of operating at pressures up to 500 lb. per sq. in. Reference is also made to various special gear pumps that have been supplied, and viscosity conversion and other useful tables concerned with pump applications are included.

Derota Type 95 Transfer Press

In MACHINERY, 99/918—18/10/61, it was erroneously stated that the new Derota type 95, 5-station, transfer press has been introduced by Platarg Engineering, Ltd., 14-24 Mund Street, London, W.14, and that sales are handled by Headland Engineering Developments, Ltd., 45 Lower Marsh, London, S.E.1. We have been asked to point out that, the press has, in fact, been introduced by E. W. Bliss (England), Ltd., City Road, Derby, and that this company handles the sales in all countries except those in Europe. Headland Engineering Developments, Ltd., have no longer any connection with Derota transfer presses. The new press is sold in Europe under the name Platarg by Platarg Engineering, Ltd.

Multiple-barrel Finishing Machine

We have been asked to point out that the multiple-barrel finishing machine, which was described in MACHINERY, 99/368—16/8/61, is protected by British Patent No. 811778, held by Redgrave, Dean & Co., Ltd., Station Road, Coleshill, Warwickshire. Enquiries for such machines should be addressed to this company.

Coming Events

INSTITUTION OF PRODUCTION ENGINEERS. *Nottingham Section.* November 1, at 7 p.m., at the Nottingham Reform Club, Victoria Street, Nottingham; lecture on "Fabrications in Aircraft Gas Turbine Engines," by W. E. Corbitt. *London Section.* November 6, at 7 p.m., at the Royal Aeronautical Society, 4 Hamilton Place, W.1; lecture on "Cold Forging," by F. Griffiths.

Books Received

FOUNDATIONS AND SOIL PROPERTIES. By Rolt Hammond, A.C.G.I., A.M.I.C.E. Macdonald & Co. (Publishers), Ltd., 16 Maddox Street, London, W.1. 181 pp. [Price 30s. 0d. net.]

Where high buildings are to be erected in towns or newly developed areas for industrial or residential purposes, the consideration of soil properties and suitable foundations is essential. In this book, the author has covered the subject concisely. The nature of soil formation and the testing of soil properties both on site and in the laboratory are described. Various formations are then considered, also procedures for overcoming undesirable tendencies. Amongst the methods discussed are grouting, piling, and stabilizing.

Scrap Metals

†LONDON.—‡Prices per ton for non-ferrous scrap metals free from iron are as follows:—Clean copper wire, untinned and free from lead and solder, £195; clean heavy copper, untinned and free from lead and solder, £188; copper wire No. 2, £180; clean light copper, £178; braziery copper, £153; gunmetal, £166; brass, mixed, £123; lead, net, £50; zinc, £30; cast aluminium, £80; old rolled aluminium, £90; battery lead, £25; unsweated brass radiators, £98; hollow pewter, £570; black pewter, £450.

† George Cohen, Sons & Co., Ltd., 600 Wood Lane, London, W. 12
‡ Subject to market fluctuations.

MIDLANDS.—The lack of confidence in current market prices of most metals continues. In particular, there is hesitation at the moment in connection with tin, an anticipated rise being slow to come into effect. It is likely, however, that in the near future there may be a clearer indication of the future trend. Copper and copper base alloys have strengthened slightly. Interest is keen and buyers are anxious to obtain good quality material. In general, trade is steady, but a cautious note is still apparent, partly on account of labour disputes which still remain to be settled.

The position as regards grades of scrap mainly affected by market conditions is as follows:—

Copper.—For the better grades of No. 1 wire and heavy scrap there have been increases of about £3 to £4 per ton. No. 2 wire and braziery material, however, do not command any higher prices and are generally out of favour.

Brass.—There is a fair demand for mixed scrap but prices tend to vary considerably and do not always follow the stronger tone of copper.

Gunmetal.—The market is still somewhat depressed with hardly any change in values.

Lead.—There has been a slight recovery of about £1 per ton, but demand does not inspire any hope of continued improvement.

Aluminium.—The market remains dull, and unattractive prices are being offered by users who must be carrying fairly large stocks.

Zinc.—Prices have eased slightly owing to some reduction in demand.

Whitemetals.—Although values remain high, the market has weakened on account of the fall in tin.

Scientific Manpower—Supply and Demand

(*Continued from page* 943)

vocational employment." Accepting the fact that some overall surplus, as opposed to an overall deficiency, may be desirable, it will be essential to ensure that the training facilities are so apportioned that within the general surplus, deficiencies in important branches do not continue to exist. In particular, as Mr. Burke has emphasized, much more attention must be paid proportionately to the instruction of future production engineers. With an adequate supply of scientists and technologists generally, it is reasonable to suppose that there will be a considerable expansion in the scale of basic and applied research which will permit more rapid advances in design and in manufacturing methods. If the necessary number of fully trained production engineers is not available, however, there may be excessive delays in the introduction of improved products and in the exploitation of new techniques to achieve the advances in industrial productivity which are so urgently needed.

Machine Tool Share Market

Apart from the gilt-edged section which maintained a very firm tone, quiet and mainly depressed conditions prevailed in stock markets during the period under review.

British Government stocks attracted a sustained investment demand, and attention was also given to home corporation and Dominion loans which led to improvements in values.

Industrial markets were dull and unsettled, and for the most part share prices moved to lower levels. There was some resistance to the downward drift, but changes on balance were irregular with declines predominating.

Among machine tool issues, Abwood Machine Tool lost 3d. at 1s. 3d.; Edgar Allen, 1s. 6d. at 31s. 6d.; Arnott & Harrison, 6d. at 10s.; Asquith Machine Tool, 1s. 6d. at 10s.; British Oxygen, 1s. 6d. at 14s. 6d.; Broom & Wade, 3s. at 24s.; Chas. Churchill, 6d. at 8s. 4½d.; Coventry Gauge & Tool, 1s. 1½d. at 29s. 1½d.; Craven Bros. (Manchester), 9d. at 7s. 1½d.; Greenwood & Batley, 1s. at 15s. 3d.; Alfred Herbert, 5s. 6d. at 60s.; Kerry's (Gt. Britain), 9d. at 7s. 6d.; Noble & Lund, 9d. at 5s.; Samuel Osborn, 1s. 3d. at 46s. 3d.; Sanderson Kayser, 1s. at 35s.; John Shaw & Sons (Wolverhampton), 6d. at 14s. 7½d.; Scottish Machine Tool, 1s. 3d. at 7s. 3d.; Tap & Die Corporation, 6d. at 16s. 3d.; and Thos. W. Ward, 1s. 3d. at 67s. 6d. On the other hand, B. & S. Massey advanced 6d. to 11s.

MARTIN BROS. (MACHINERY), LTD.—Dividend 3d. per share for the year to June 30.

WADKIN, LTD.—Interim dividend 4 per cent.

New Companies Registered*

FARNWORTH GRINDING CO., LTD., 20 Gladstone Road, Farnworth, Bolton, Lancs. Registered September 28, 1961. To carry on the business of precision tool grinders, etc. Nom. cap.: £1,000 in £1 shares. Directors: Geoffrey Schofield and Frank Fawcett.

H. SOLLEY, LTD., 20 North Street, Brighton, Sussex. Registered September 28, 1961. To carry on the business of engineers, turners, grinders, welders, etc. Nom. cap.: £1,000. Directors: H. Solley and Mrs. E. Solley.

BROOKS & BROWN (WITNEY), LTD., 100 High Street, Witney, Oxon. Registered September 29, 1961. To carry on the business of precision engineers, etc. Nom. cap.: £2,000 in £1 shares. Directors: T. J. Brooks, E. Brooks, H. Brown, and E. E. Braine.

* From the lists compiled by Jordan & Sons, Ltd., Company Registration Agents, 116-118 Chancery Lane, London, W.C.2.

COMPANY		Denom.	Middle Price
Abwood Machine Tools, Ltd.	Ord.	1/-	1/3
Allen (Edgar) & Co., Ltd.	Ord.	£1	31/6
" "	5% Prf.	£1	13/3
Arnott & Harrison, Ltd.	Ord.	4/-	10/-
Asquith Machine Tool Corp., Ltd.	Ord.	5/-	10/-
" " "	6% Cum. Prf.	£1	16/6
Birmingham Small Arms Co., Ltd.	Ord.	10/-	20/-
" " "	5% Cum. "A" Prf.	£1	12/6
" " "	6% Cum. "B" Prf.	£1	15/6
" "	4% 1st Mort. Deb.	Stk.	91½
British Oxygen Co., Ltd.	Ord.	5/-	14/6
" " "	6% Cum. Prf.	£1	18/6
Brooke Tool Manufacturing Co., Ltd.	Ord.	5/-	8/-
Broom & Wade, Ltd.	Ord.	5/-	24/-
" "	6% Cum. Prf.	£1	16/6
Brown (David) Corporation, Ltd.	5½% Cum. Prf.	£1	14/-
Buck & Hickman, Ltd.	6% Cum. Prf.	£1	17/-
Butler Machine Tool Co., Ltd.	Ord.	5/-	15/-
" " "	5% Cum. Prf.	£1	12/6
Churchill (Charles) & Co., Ltd.	Ord.	2/-	8/4½
" " "	6% Cum. Prf.	£1	25/7½‡
Clarkson (Engrs.), Ltd.	Ord.	1/-	6/3
Cohen (George), 600 Group, Ltd.	Ord.	5/-	10/-
" " "	4½% Cum. Prf.	£1	11/6
Coventry Gauge & Tool Co., Ltd.	Ord.	10/-	29/1½
" " "	5% Cum. Red. Prf.	£1	16/3
Craven Bros. (Manchester), Ltd.	Ord.	5/-	7/1½
Elliott (B.) & Co., Ltd.	Ord.	1/-	2/6
" "	4½% Red. Cum. Prf.	£1	11/3
Firth Brown Tools, Ltd.	4% Cum. Prf.	£1	10/-
Greenwood & Batley, Ltd.	Ord.	10/-	15/3
Harper (John) & Co., Ltd.	Ord.	5/-	7/9
" " "	4½% Red. Cum. Prf.	£1	9/6

COMPANY		Denom.	Middle Price
Herbert (Alfred), Ltd.	Ord.	£1	60/-
Holroyd (John) & Co., Ltd.	"A" Ord.	5/-	20/-
" "	"B" Ord.	5/-	16/3
Jones (A. A.) & Shipman, Ltd.	Ord.	5/-	25/6
" " "	7% Cum. Prf.	5/-	4/6
Kearney & Trecker-C.V.A., Ltd.	5½% Red. Cum. Prf.	£1	8/9
" " "	Prefd. Ord.	£1	13/9
Kearns (H. W.) & Co., Ltd.	Ord.	5/-	21/3
Kerry's (Gt. Britain), Ltd.	Ord.	5/-	7/6
Macreadys Metal Co., Ltd.	Ord.	5/-	15/-
Martin Bros. (Machinery), Ltd.	Ord.	2/-	2/6
Massey (B. & S.), Ltd.	Ord.	5/-	11/-
Newall Engineering Co., Ltd.	Ord.	2/-	7/-
Newman Industries, Ltd.	Ord.	2/-	7/-
" "	6% Prf. Ord.	5/-	5/-
Noble & Lund, Ltd.	Ord.	2/-	5/-
Norton, W. E. (Holdings), Ltd.	Ord.	2/-	8/-
Osborn (Samuel) & Co., Ltd.	Ord.	5/-	46/3
" " "	5½% Cum. Prf.	£1	22/-
Pratt (F.) Engineering Corporation, Ltd.	Ord.	5/-	14/6
Sanderson Kayser, Ltd.	Ord.	10/-	35/-
" "	6½% Cum. Prf.	£1	16/3
Scottish Machine Tool Corporation, Ltd.	Ord.	4/-	7/3
Shardlow (Ambrose) & Co., Ltd.	Ord.	£1	50/7½
Shaw (John) & Sons, Wolverhampton, Ltd.	Ord.	5/-	14/7½
Sheffield Twist Drill & Steel Co., Ltd.	Ord.	4/-	19/-
" " "	5% Cum. Prf.	£1	13/3
Stedall & Co., Ltd.	Ord.	5/-	7/9xd
Sykes (W. E.), Ltd.	"B" non-voting Ord.	10/-	25/7½
Tap & Die Corporation, Ltd.	Ord.	5/-	16/3
" " "	4½% Deb. 1961-1977	Stk.	81½
Wadkin, Ltd.	Ord.	10/-	26/-
Ward (Thos. W.), Ltd.	Ord.	£1	67/6
" "	5% Cum. 1st Pref.	£1	13/6
" "	5% Cum. 2nd Pref.	£1	20/-
Willson Lathes, Ltd	Ord.	1/-	3/-

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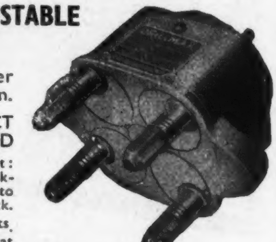

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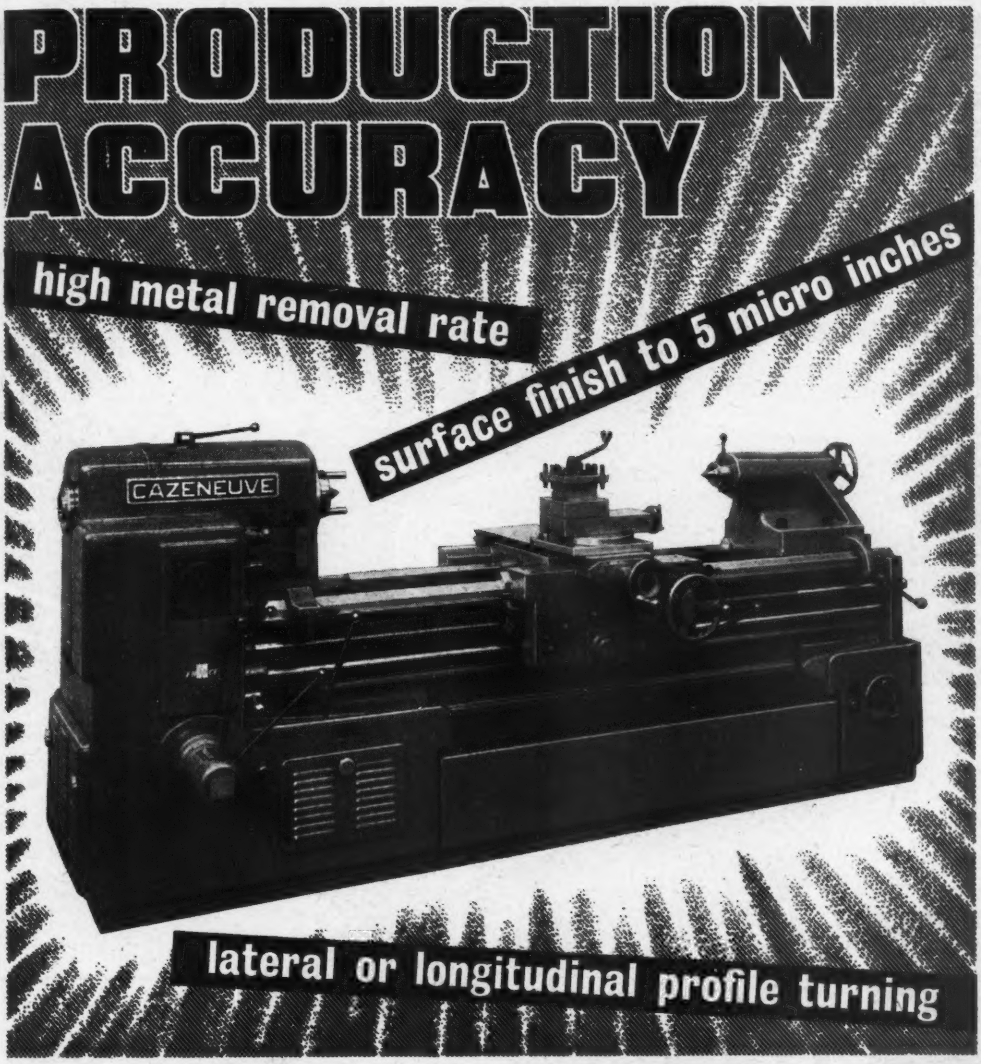

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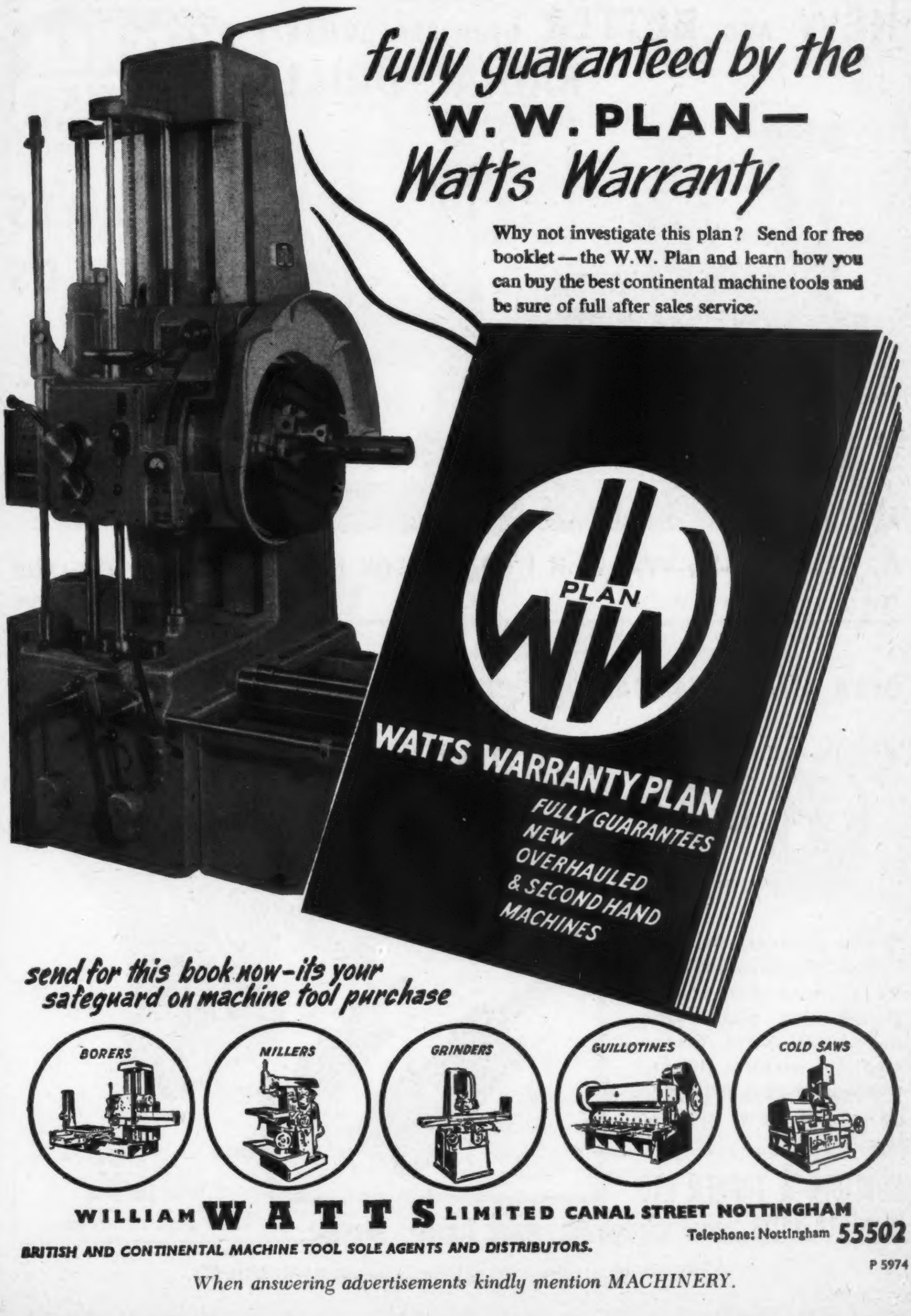
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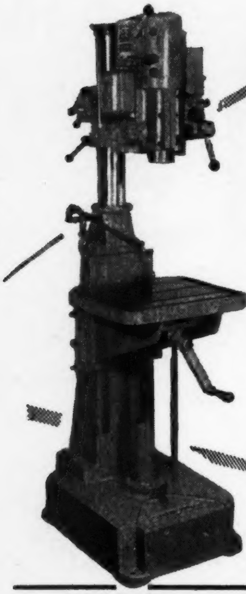

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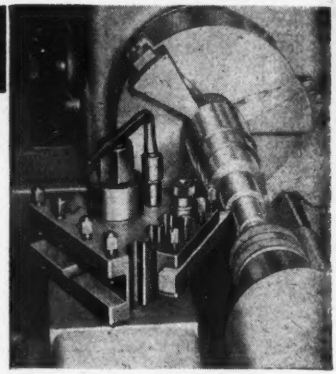
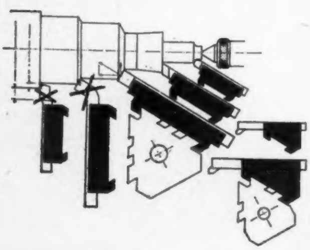


The TRIPAN (patented) system comprises a triangular clamping block and a range of interchangeable toolholders. The clamping block is selected according to the centre height of the lathe and the toolholders according to the size of the cutter and the work to be done.



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This diagram shows—on the right—the correct TRIPAN cutting positions. Note the reduced tool overhang and how the full cutting power is utilised. Avoid cranked tools and the cutting positions shown on the left—these are inefficient.

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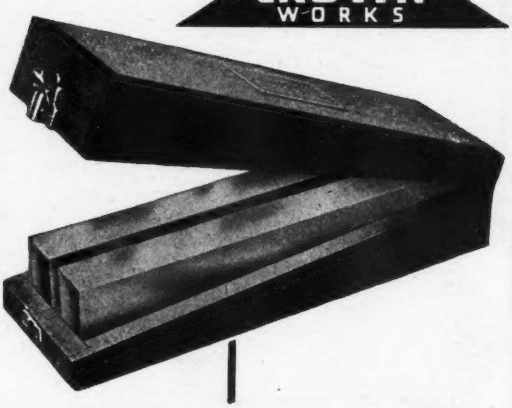

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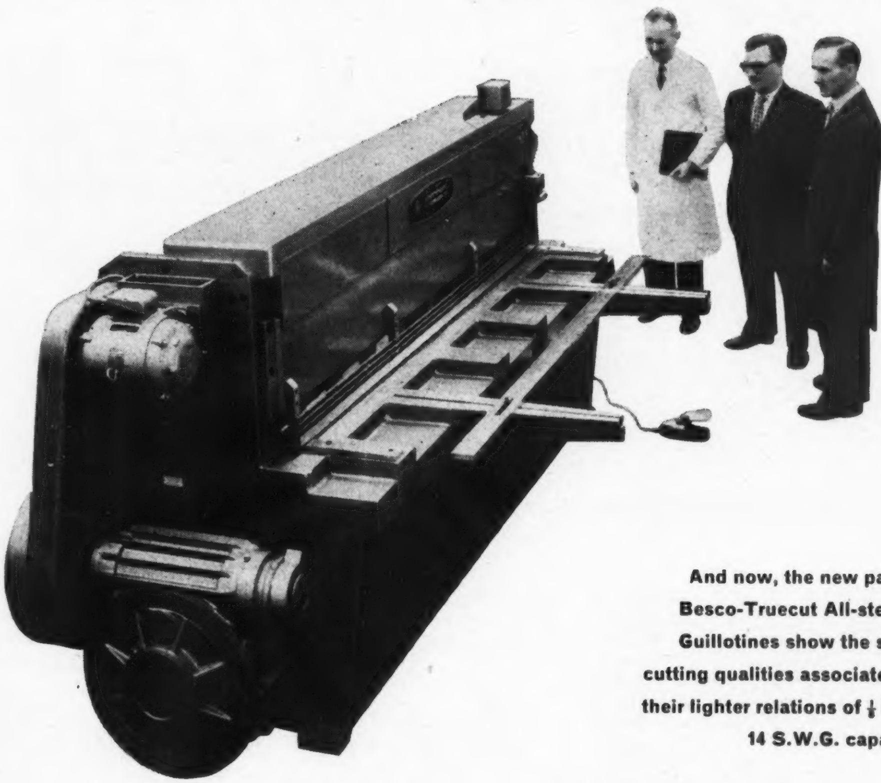

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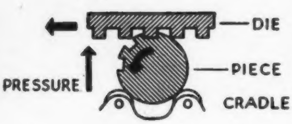
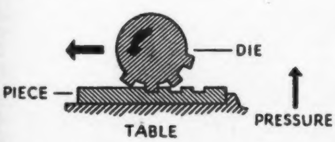


Each round part is located in a cradle and is raised under pressure against a flat die carried in the head. The die then traverses and the impression is made in the part smoothly and evenly.



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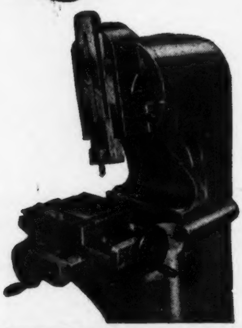

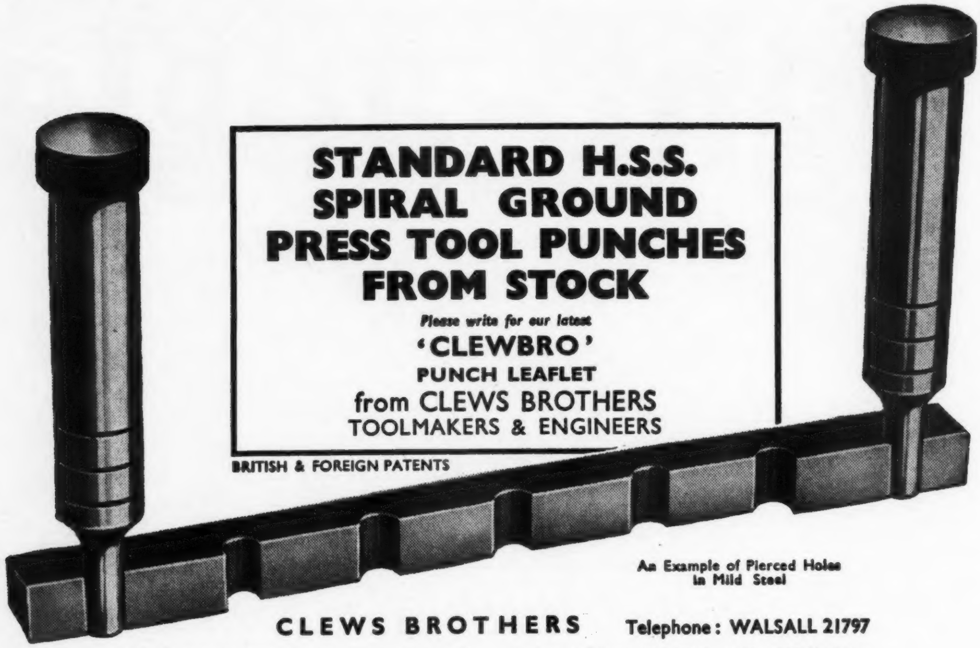

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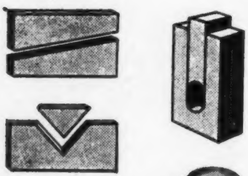

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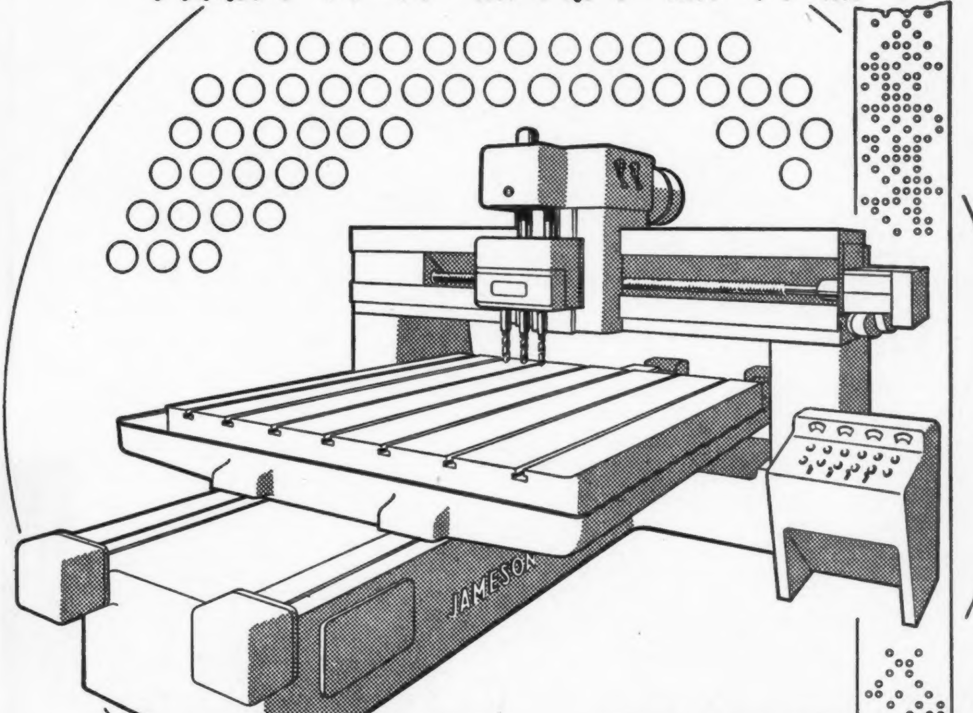

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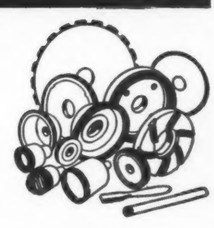

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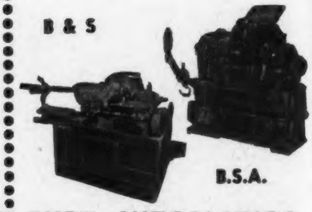

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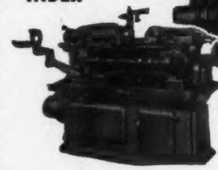

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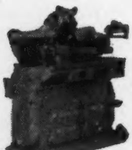

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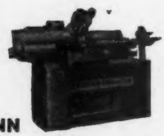

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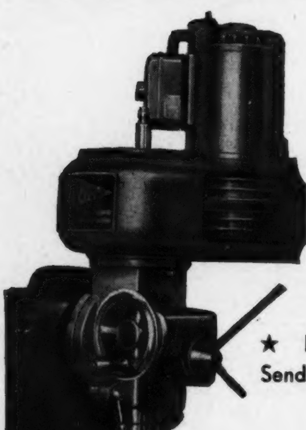

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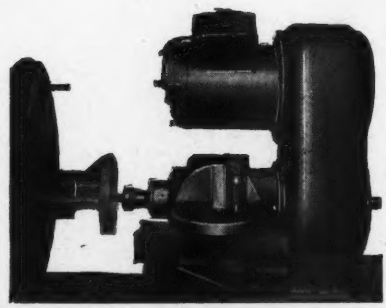

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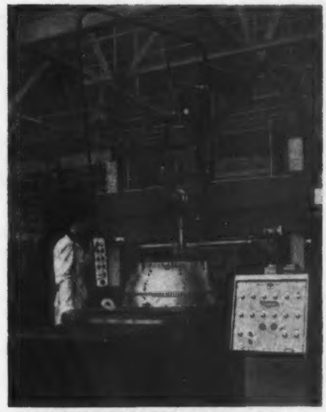

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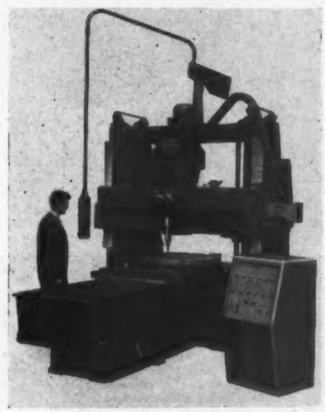

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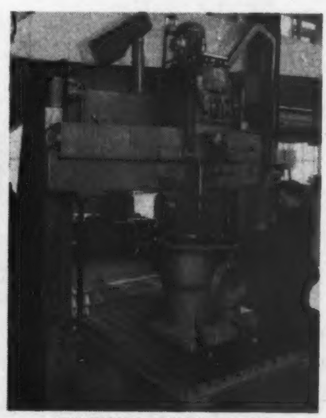

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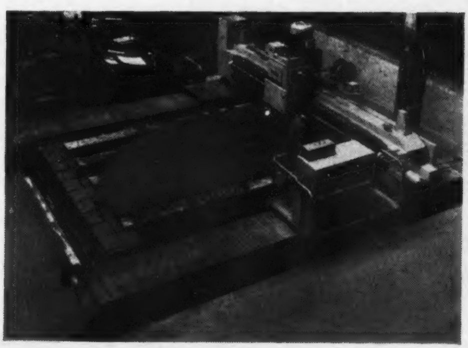

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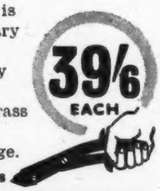

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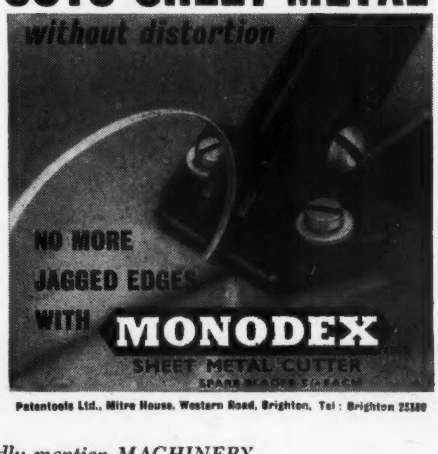

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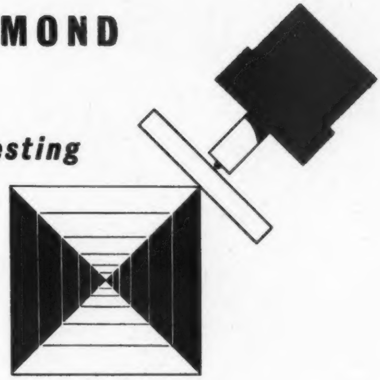

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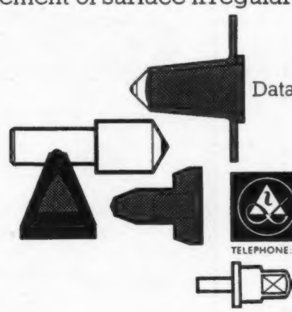

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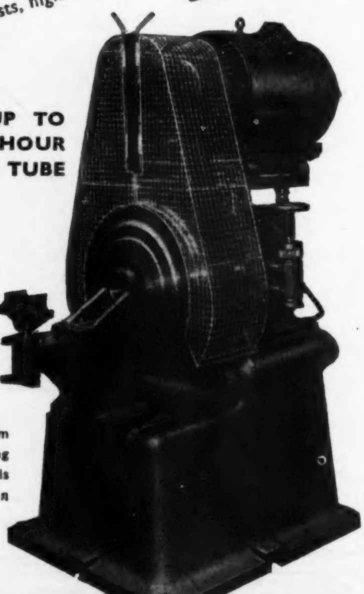

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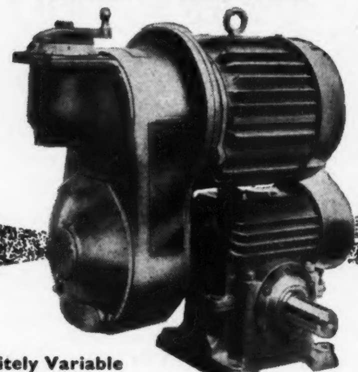

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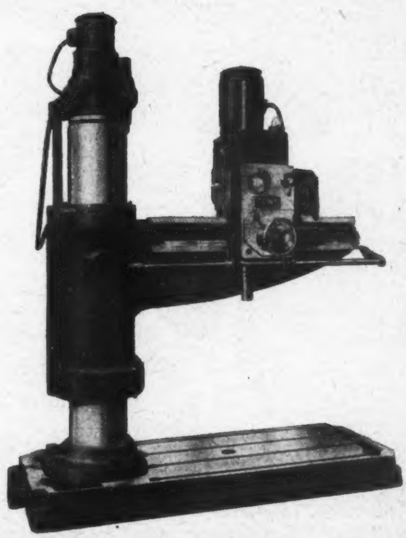

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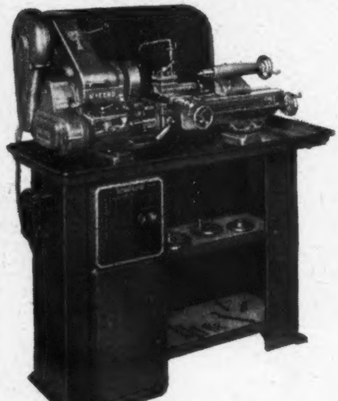

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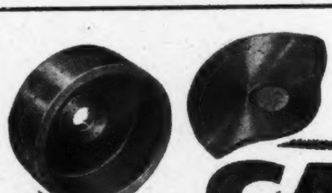

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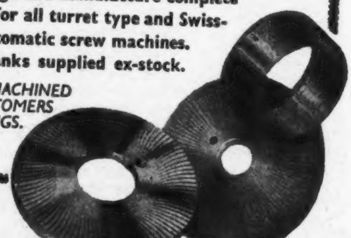

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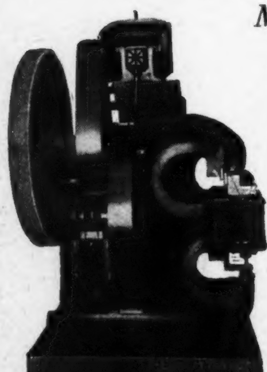

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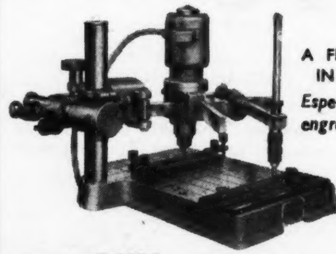

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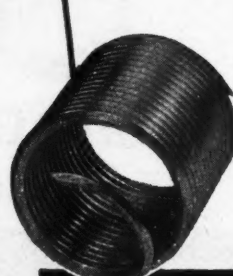

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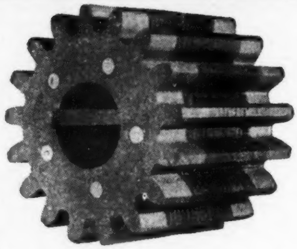

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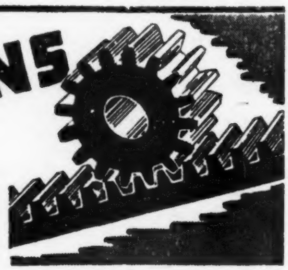

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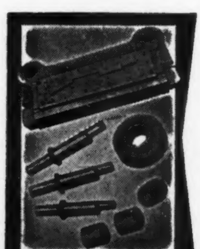

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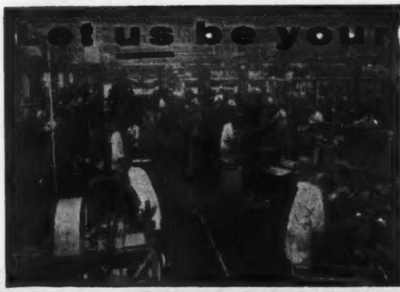

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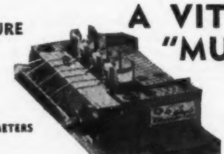

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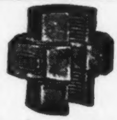

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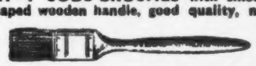

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ASQUITH HKO Duplex Keyseater.

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Sunstrand Model 8 Automatic lathe.—C. DUGARD LTD., Denmark Villas Hove 32471.

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New **WILLSON** Mark 1 6½in. Sloping Bed Lathe, A.G.H. S.S. & S.C. Gap Bed to admit 2ft. 6in. between centres.
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MITCHELL OF KEIGHLEY 10½in. S S. & S.C. Lathe to admit 4ft. 0in. between centres.
VOLMAN 8in. S.S. & S.C. Gap Bed Lathe to admit 4ft. 6in. between centres.

BORING MACHINE

WEBSTER & BENNETT 36in. Vertical Boring Mill, table speeds 5.6/125 r.p.m.

DRILLING MACHINES

ARCHDALE 5ft. Elevating Arm Radial Drilling Machine. No. 5 M.T. spindle.
New **RICHMOND** Model SR.2 3ft. 0in. Radial Drilling Machine. Fixed arm No 3 M.T. spindle.
SWIFT 4ft. 6in. Model A1 Elevating Arm Radial Drilling Machine, No. 4 M.T. spindle, motorised 400-440/3/50 cycles.
New **KITCHEN-WALKER** 4ft. 6in. Radial Drilling Machine, No. 5 M.T. spindle.

GRINDING MACHINES

BROWN & SHARPE No. 5 Horizontal Spindle Surface Grinding Machine, 24in. × 8in. capacity. hydraulic feed to table.
JONES & SHIPMAN Vertical Spindle Surface Grinding Machine, 18in. × 6in., hydraulic feed to table.
NORTON 6in. × 30in. Hydraulic Plain Cylindrical Grinding Machine, maximum wheel diameter 20in.

MILLING MACHINES

CINCINNATI No. 4 Horizontal Plain Milling Machine, 78½in. × 16in. table.
HYPERMILL 7/27 Production Type Milling Machine, 43in. × 10in. table.
MIDGLEY & SUTCLIFFE Hand Lever Feed Milling Machine, 16in. × 5in. table.
EDGWICK No. 2 Dial Type Plain Horizontal Milling Machine, 46in. × 11in. table.
ARCHDALE 20in. Dial Type Horizontal Milling Machine, 40in. × 12in. table.
GREENWOOD & BATLEY Plain Horizontal Milling Machine, working surface of table 20in. × 10in.
EDGWICK 18in. Horizontal Plain Production Milling Machine, with 40in. × 12in. table.

POWER HAMMERS

ALLDAYS & ONIONS 2 cwt. Clear Space Type Pneumatic Power Hammer.
MASSEY 5 cwt. Pneumatic Side Type Power Hammer.

SAWING MACHINES

New **WICKSTEED** 10in. capacity Power Hacksaw.
New **STARTRITE-SABRE** Vertical Metal Cutting Bandsaw, 20in. throat.

SLOTTING MACHINES

BUTLER 14in. stroke All Geared Slotting Machine with 39in. diameter rotary table.
DUTRANNOIT 24in. stroke Precision Slotting Machine with swivelling head, 39½in. table.

SHAPING MACHINE

New **INVICTA** 24in. and 18in. stroke Shaping Machines.

SHEARING MACHINE

New **KEETONA** 8ft. 0in. × ¼in. Undercrank Guillotine Shearing Machine.

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BRONX 8ft. 0in. × ¼in. Straightening Rolls, 5 roll type.

All the above machines are motorised 400-440/3/50 cycles.

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AUTOMATICS

CLEVELAND 3¾in. capacity Automatic.

BORING MACHINES

GIDDINGS & LEWIS No. 25RT. Horizontal Boring Machine. Travelling Spindle and Facing Head. No. 4 Morse Taper. Spindle dia. 2¼in. Top Table 24in. by 24in.
HEALD No. 49. Borematic.

DRILLING MACHINES

ADCOCK & SHIPLEY 28in. Heavy Duty Vertical Drilling Machine. No. 4 Morse Taper.
BAKER Heavy Duty Vertical Drilling Machine. No. 3 Morse Taper.

GEAR CUTTING MACHINES

DAVID BROWN M.T. 15 Gear Hobbing Machine.
DAVID BROWN M.T.30 Gear Hobbing Machine. 1950.

GRINDING MACHINES

MATRIX 10 by 16 Thread Grinding Machine.

LATHES—CAPSTAN AND TURRET

WARD 3A Capstan Lathe.
HERBERT No. 9 Combination Turret Lathe. 4¼in. Spindle Bore.
WARNER & SWASEY 4A Turret Lathe. 8in. Spindle Bore.

LATHES S.S. & S.C.

MONARCH 7in. by 30in. S.S. & S.C. Lathe. Fully equipped.
LE BLOND 11½in. by 96in. S.S. & S.C. Lathe. Fully equipped.
SWIFT 12½in. by 10ft. 6in. S.S. & S.C. Gap Bed Lathe. Spindle Bore 4¼in.

LATHES—GENERAL

CHURCHILL-REDMAN S.S. & S.C. Boring Gap Bed Lathe. 24in. swing over Saddle. 3¼in. Spindle bore.

MILLING MACHINES

MILWAUKEE 2K Vertical Milling Machine.
CINCINNATI No. 3 Dial Type High Speed Vertical Milling Machine.
CINCINNATI No. 3 Dial Type Medium Speed Vertical Milling Machine.

PLANING MACHINES

BUTLER 14ft. by 5ft. by 5ft. Heavy Duty Double Column Planing Machine.
KENDALL & GENT Horizontal Spindle Openside Plano Milling Machine. Table size 36in. by 120in.

SCREWING MACHINES

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SHAPING MACHINES

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CHURCHILL-REDMAN 18in. Heavy Duty Shaping Machine. Equipped with swivelling table and machine vice.
CHURCHILL-REDMAN 24in. Heavy Duty Shaping Machine. Equipped with swivelling table and machine vice.
KELLY 28in. Heavy Duty Shaping Machine.

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BESCO No. 36, 36in. Production Gang Slitting Machine.
TAYLOR & CHALLEN 563, 100 ton Coining Press.

Cincinnati No. 3 Dial-type Universal Milling Machine. Table 62½in. × 15½in., 21 speeds 18-1,300 r.p.m. With 12in. universal dividing head, vertical milling head. Post-war machine, in excellent condition.—LEE & HUNT, LTD., Crocus Street, Nottingham. 'Phone: 84246.

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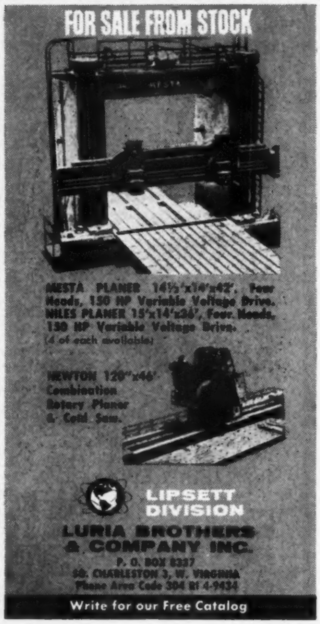

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AE4 BECHLER 1 spindle attachment
CLEVELAND Model A. 2¼in. capacity
INDEX 24 mm single. Reconditioned

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⅞in. **B.S.A. ACME GRIDLEY** RA 6 spindle. Screwing spindle, Collets and Tooling. 3 available. 1944-1948.
1¼in. **CONOMATIC** 8 spindle with srcewing spindle, thread rolling, tooling and collets.
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⅞in. **ACME GRIDLEY** 4 spindle, G Model Bar Auto. £450.

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LAPOINTE Vertical 8 ton, 36in. stroke.
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New **B.E.N.** Compressors in stock, type VR 32 cfm, 100 lb. working pressure and type VR 41 cfm 100 lb. working pressure.

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HERBERT J TYPE. Single Column and two column machines.
ARCHDALE Snout Type Electrically Controlled Vertical Borer, 50 Int. Taper.
LELAND GIFFORD 2 Spindle No. 2 Morse Taper.
ASQUITH Horizontal Duplex M/c. No. 5 Morse, 5ft. dia. Rotary table.
ARCHDALE 2 spindle, mounted on a bridge with swivelling and centre distance adjustment. Power traverse to quills. No. 4 Morse. Table 92 in. by 13in. working surface.
CORONA 2 Spindle 15CK, No. 3 Morse.
ARCHDALE UGD Power Feed, No. 4 Morse Taper.

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TOWN 5ft. Radial.
KITCHEN & WADE 40in. Arm. Power Rise and Fall. Speeds 1,500 r.p.m. No. 3 Morse. Suds.
ASQUITH 6ft. D.C. Drive. £400.
ASQUITH OD2. 8ft.

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MIKRON type 79.
CLEVELAND 130D.
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GLEASON 3in. Bevel Gear Generator and equipment.
LORENZE SOO High Speed Gear Shaper, Rebuilt.
FELLOWS Gear Shaper No. 7.

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PRECIMAX SP 1½, 7in. by 12in. Recond.
PRECIMAX MPL., 6in. by 24in. Plunge.
NORTON 6in. by 24 in.
CHURCHILL 6 by 18 Hydraulic feed, hydrauto bearings.

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DOALL 20 in. by 6in. Hydraulic Feed.
JONES & SHIPMAN Fig. 540. 6in. by 18in. Coolant Tank, Pump & Dust Extractor.
BLANCHARD 10C. 6in. Magnetic Rotary Table.

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JONES & SHIPMAN 10in. by 27in.
HENRI KAESER Model L. 10 by 20.
BROWN & SHARPE No. 13.

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HAHN & KOLB 26in. dia. with Coolant Filter Plant. Reconditioned.
PETER WOLTERS Hydraulic. Two Spindle Vertical Honing Machine.
NEWALL Hydro Lapper 24in. dia. of table, approx. 8 years old.

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THIEL Model 58 Tool Room Mill.
WADKIN High Speed Vertical Table 35in. by 13in.
CINCINNATI No. 3 Vertical Sliding head (overhauled).
ALEXANDER No. 2, 3 Dimensional Pantograph Machine.
CENTEC 2A Horizontal.
HERBERT No. 1 Hand Mill.
EDGWICK Horizontal Machine.

CAPSTAN AND TURRET LATHES

HERBERT No. 4, Senior Eloptive.
HERBERT No. 0.
HERBERT No. 13 Bar Turret.
GISHOLT No. 3 A.G.H. Capstan (Collet).
GISHOLT No. 3 Simplified Capstan.
GISHOLT IL 3in. hole through spindle.
Plating **SELENIUM RECTIFIER** 1000 amps
ATLAS 1B 1in. capacity.
MODERN No. 1.
MURAD 3Q ⅝in. capacity.
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WARD 3A Capstans.
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HILLE 6in. O/D Max.
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WICKMAN Moulton.
ARCHDALE with 120 Hobs.
WANDERER. 3in. capacity.

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TAYLOR & CHALLEN Type 1413 40 ton Variable stroke—Guards.
85-ton **RHODES** Upright Geared.
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FLY PRESSES Nos. 3, 6.
HENRY & WRIGHT Dieing Press, 25 tons.
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ALBA 14in. stroke.
ALBA 10in. stroke.

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BUTLER RAPID 8in. Tool Room Machine.
BUTLER PRECISION 4in.

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BRITISH ELECTRIC Oil Cooled, high volt 415. 70 Kva. 13 tappings.

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40 Kva **NEW PROCESS** Spot Welder.

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Double Ended Angle Cropping Machine. Cap. up to 6in. × ⅝in. angles.

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AMERICAN 6ft. Heavy Duty Radial Drill. No. 6 M.T. Older machine, good condition. 400/3/50, separate motor.

GRINDING MACHINE

NEW N.I. 10in., 12in., 14in., 16in and 20in. D/E Tool Grinders.

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SPEEDAX 9in. Power Hacksaw.

LATHE

HERBERT No. 4 Capstan. 2½in. H/Spindle. Speeds—511.

MILLING MACHINE

MILWAUKEE 3H Horizontal Milling Machine. Table 64in. × 13½in.

NIBBLERS

BURFREE 2A Nibbling Machine. Cap. ⅛in. M/S.
W.F. 14 Gauge Nibbler. 59in. throat.

PRESS

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SCREWING MACHINE

KENDALL & GENT 3in. Screwing Machine. Leadscrew type.

SHAPING MACHINE

TOWN 26in. Heavy Duty Shaper.

WELDING EQUIPMENT

PRESCOTT 15 kVA Spot Welder.

All machines 400/3/50 electrics unless otherwise stated

THE

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Kitchen & Wade H5 Horizontal Boring and Drilling Machine, complete with Square Box Table and Auxiliary Revolving Table. Machine equal to new.

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Pratt & Whitney 4½in. × 12in. Universal Thread Miller. 400/3/50.—HICKS MACHINERY, LTD., 26, Addison Place, London, W.11. Tel.: PARk 2333.

WILSON 7½in. Centre Lathe, 30in. between centres. 9 spindle speeds 26-477 r.p.m. Hole through spindle 2½in. dia. Latest type machine. 400/3/50.
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BROOKES Overcrank Double Geared Power Guillotine, capacity 4ft. × ¼in. Powered work table (in two sections) 24ft. long approx. × 4ft. wide. 20 h.p. 400/3/50.

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8in. Centre "Reed-Prentice" m/d all-geared S.S. & S.C. Lathe. Admits 4ft. 6in. b.c., 16 speeds 18-536 r.p.m. Spindle bored 1⅜in. dia. mounted in "Timken" roller bearings. Norton type gearbox.—LEE & HUNT, LTD., Crocus Street, Nottingham. Phone: 84246.

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MILWAUKEE Model 2HL *VERTICAL MILLING MACHINE*, with swivelling head. Table size 9in. × 44½in. Speeds 35 to 1,400 r.p.m. Dial type selection. Rapid traverse in all directions. Motor drive 400/3/50. Price: £1,050

MITCHELL 8½in. All Geared Head S.S. & S.C. *GAP BED CENTRE LATHE*. Admits 4ft. 4in. between centres. 3½in. hollow spindle. Swing in gap 32in. 8 spindle speeds 30 to 400 r.p.m. Fitted with quick change gearbox. Motor drive 400-440/3/50. Price: £675

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MANURHIN Type PD12A Automatic with Hopper feeds for parting off and chamfering Cartridge Case heads. 5 machines. (These nearly new machines may be adapted for other work and are offered at the lowest price.)
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MURAD ⅜in. capacity with full equipment.

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HANDS 4ft. by ⅛in. Guillotine.
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HOLROYD PLANO MILLING MACHINE, capacity 17ft. 6in. by 9ft. 6in., 2 heads on cross rail with 25 h.p. drive, pendent control, weight 50 tons. (Modern machine).

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RHODES 1-Ton Open Fronted Bench Press with flange motor and UDAL guards.
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LEE & CRABTREE 20-Ton Horning Press.
LEE & CRABTREE 35-Ton Double Action Mechanical Press.
H.M.E. Model DCP3 70-ton Double Sided, Double Crank, Single Action Power Press.
Six New **MULLER** Model AMP 22-ton Power Presses. Complete with horn.
Three New **MULLER** Model AMP 35-ton Power Presses.
Two New **MULLER** AMP 45-ton Power Presses.
Two New **MULLER** AMP 60-ton Power Presses. Open Fronted.
Two New **MULLER** AMP 80-ton Power Presses.

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BERRY 16in. Shaper.
BROOK 18in. Shaping Machine.
KLOPP 22in. Shaping Machine.
TORPEX 22in. Shaping Machine.
New **LIMA** 22in. Shaper.

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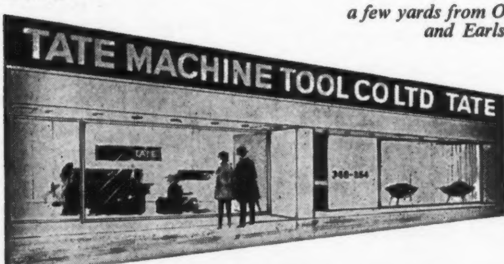
WESPA AS4 Bandsawing and Bandfiling Machine, hydraulic feed (similar Do-all V/16).

WATCHMAKERS' MACHINES

MIKRON No. 79 Gear Hobber (almost new).
SAFAG Model 24 Automatic Cutter Relieving Machines.

a few yards from Olympia and Earls Court



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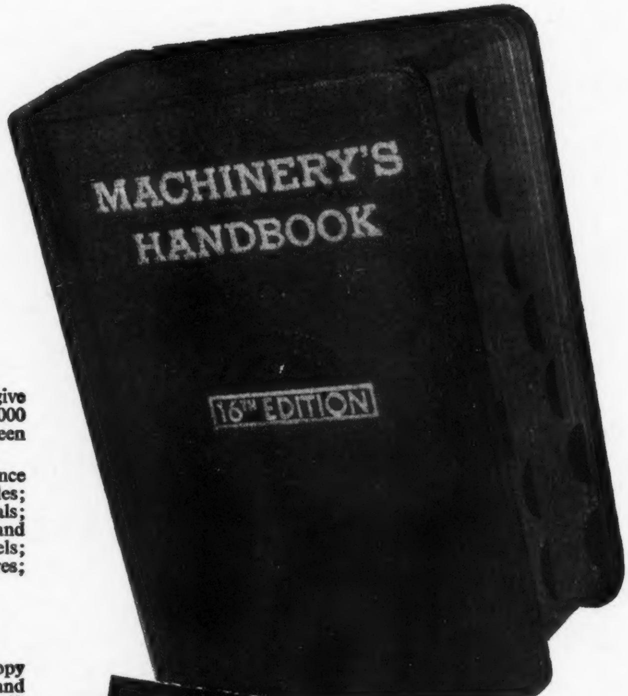

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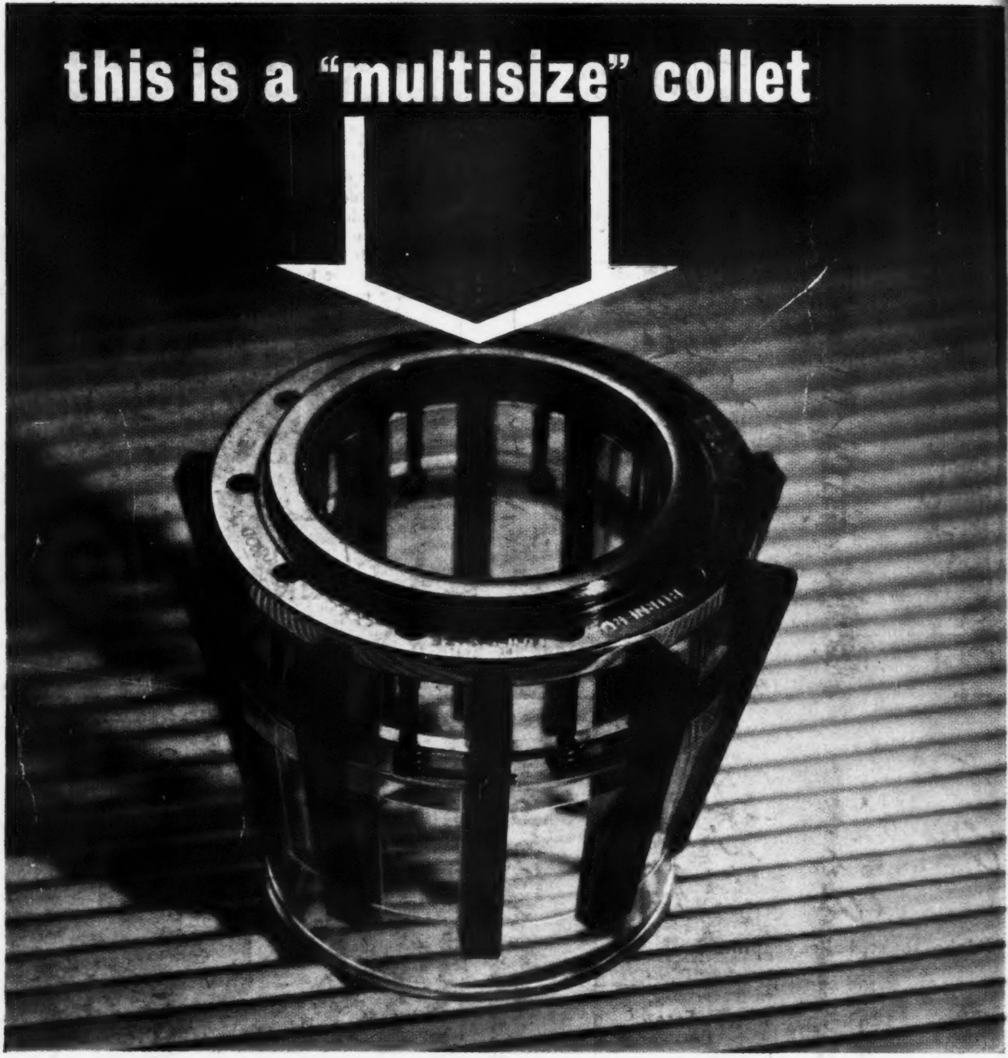

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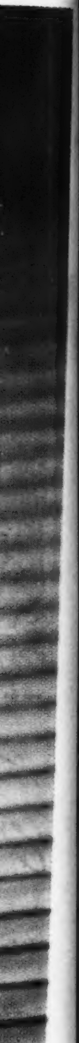

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